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A

# DICTIONARY OF PHOTOGRAPHY.

By THOMAS SUTTON, B.A.

# A DICTIONARY

OF

# PHOTOGRAPHY.

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THOMAS SUTTON, B.A.,

EDITOR OF "PHOTOGRAPHIC NOTES."

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THE CHEMICAL ARTICLES OF A, B, C, BY JOHN WORDEN.

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Illustrated with Diagrams.

LONDON:
SAMPSON LOW, SON, AND CO., 47, LUDGATE HILL.
MDCCCLVIII.

LONDON:
WILLIAM STEVENS, PRINTER, 37, BELL YARD,
TEMPLE BAR.

# PREFACE.

THIS Dictionary of Photography contains a minute account of the principal photographic processes now in use, and a description of the various substances employed by the photographer, together with an explanation of optical terms, the theory of lenses, rules of perspective, &c. No account, however, has been given of such common forms of apparatus as may be seen at every photographic depôt in the kingdom, as this would have occupied space unprofitably. My object has been to place in the hands of the practical photographer a useful book, which will assist him in the endeavour to comprehend the optical and chemical principles of his art, and save him the trouble of referring to the numerous bulky and costly works which I have been myself obliged to consult. In my description of the several PROCESSES I have given those formulæ which, while they produce the best results, involve the simplest manipulation and fewest materials, rejecting all such modifications as appear to be unsupported by sound reasoning and conclusive experiments; in the articles which treat of OPTICS I have endeavoured to explain clearly the principles of perspective, and the theories of achromatism, aberration, the production of images, and construction of lenses;—and in the CHEMICAL articles, avoiding what is hypothetical and uncertain, I have confined myself to the description of the known properties and photographic uses of the various substances treated of. In short my aim has been not so much to produce a work abounding with novelties, hypotheses, and suggestions, as one containing a plain statement of ascertained facts, and which may be relied on for accuracy.

The works which I have chiefly consulted are Dr. Ure's "Dictionary of Arts, Manufactures, and Mines," the chemical treatises of Gmelin, Liebig, Thenard, Brande, Faraday, Fownes, Pereira, Redwood, and Griffin; and the optical works and tutor's manuscripts which form part of the Cambridge course of mathematics. To Brande's admirable "Manual of Chemistry" I am perhaps more indebted than to any of the other works mentioned, and I make this acknowledgment with pleasure as I received my first lessons in chemistry from that gentleman, at the Royal Institution, some twenty years ago. I would also acknowledge in this place the assistance I have received from the valuable papers on Photographic Chemistry communicated at different times by Mr. Hardwich to the Photographic Society, and by Messrs. Davanne and Girard to the French Photographic Society. The opinions expressed in the present work with respect to the organic nature of the photographic image in all the negative processes, and the positive processes upon paper, are, I believe, fully supported by the experiments of the above named gentlemen, and may be considered as no longer hypothetical, but certainly true.

I have also to acknowledge the valuable assistance I have received from the gentleman whose name is associated with my own on the Title page, and who is the author of all the chemical articles of the letters A, B, C.

This is, I believe, the first Photographic Dictionary that has been published in Europe. A similar work was issued some years ago in America, but I have not been able to procure a copy of it.

THOMAS SUTTON.

ST. BRELADE, JERSEY,
*August* 17*th*, 1858.

# A
# PHOTOGRAPHIC DICTIONARY.

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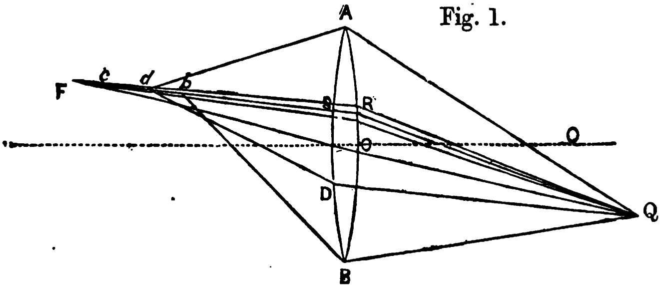
A. The termination *a*, of chemical names, signifies an oxide. Thus, Soda is an oxide of Sodium, Ammonia of Ammonium, and Baryta of Barium. Some oxides, as those of silver, gold, &c., do not take this terminal, a defect which leads to misapprehension. The Nitrate of Silver is the Nitrate of the Oxide of Silver, which would be obvious if it were called Nitrate of Argenta, just as the similar salt of Potassium is called Nitrate of Potassa.

ABERRATION. This is a term much used in Optics. When a pencil of light is refracted through a lens, or reflected from a mirror, it happens in certain cases that the directions of the refracted or reflected rays do not all pass accurately through a focus. This error is called "aberration," a term which must not be confounded with "deviation," *q. v.*

There are many kinds of aberration, but those with which the photographer is most concerned are called "spherical aberration," and "chromatic aberration."

Fig. 1.



I. *Spherical Aberration.*—This is a term exclusively employed to denote the aberration produced by the reflection or refraction of a pencil at a *spherical* surface. Thus, in Fig. 1.—

Let A B be a single convex lens, and Q A B a pencil of light incident upon it, proceeding from a luminous point Q. The pencil, after refraction through the lens, will not form a cone of light in which all the rays come to a common focus, but an effect will take place which it is important clearly to understand. In the first place, the emergent pencil is symmetrical with respect to an axis F S, which axis produced passes through the centre O of the posterior spherical surface A S B. The refracted rays which emerge from the immediate neighbourhood of the point S form a *small* pencil, which may be considered as having a focus F, called the "geometrical focus." The outer rays of the emergent pencil will cut the line S F at points *c*, *d*, *b*, as shown in the figure; the distances F *c*, F *d*, F *b*, increasing as the distance from S of the point of emergence of a ray increases. F *b* is therefore called the aberration of the ray Q B, F *d* of the ray Q D, F *c* of the ray Q C, and so on.

When F S is large compared with S A, the aberration F *d* is proportional to the square of S A.

It is impossible to construct a single lens with spherical surfaces, so that the pencils shall be entirely free from aberration; but by combining two or more lenses, made of different kinds of glass, or of the same kind of glass, spherical aberration may be to a great extent, although not entirely, corrected. Such compound lenses, or combinations, are said to be "aplanatic," *q. v.*

There are certain forms of reflecting and refracting surfaces and lenses in which a particular pencil is reflected or refracted without aberration. The only case with which the photographer is concerned is that of the parabolic mirror. All rays which proceed from a luminous point in the focus of the mirror are reflected in directions parallel to its axis.

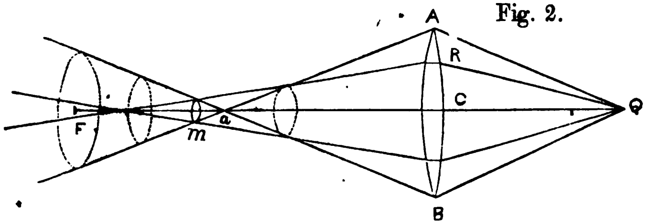
The methods usually employed for correcting spherical aberration in photographic lenses are described in the article "Lens."

It is a common error to confound spherical aberration with curvature of the image. Curvature of the image may exist where there is no spherical aberration, and *vice versâ*. *See* "Lens."

The nearest approach to a correct focus which can be obtained with a lens, when a large aperture is employed, is called the "least circle of aberration."

It will be seen in Fig. 2, that if the various rays of a refracted pencil are produced through the axis, there will be a certain position, *m*, of a circular area through which they all pass, in which the diameter of that circle will be the least possible. If F *a* is the aberration of the pencil, the distance of this least circle of aberration from F is three-fourths of F *a*; and if the aperture of the lens A B is small compared with its focal length, C F, the diameter of the least circle of aberration is proportional to the cube of the diameter of the part of the lens employed.

Fig. 2.



II. *Chromatic Aberration.*—The light which proceeds from the sun, and most luminous bodies, is found to be heterogeneous, that is, composed of different kinds of light, of different degrees of refrangibility. If a ray of such light is refracted through a prism or lens, it will be decomposed into its constituent rays; and if it be a direct pencil passing through a lens, there will be formed a system of emergent pencils, corresponding to the different kinds of light of which the incident pencil is composed. Sunshine is found to be composed of light of seven different colours, viz., red, orange, yellow, green, blue, indigo, violet, arranged in the order of their refrangibility, red being the least, and violet the most refrangible. When, therefore, a pencil of sunshine is refracted through a convex lens, the foci of the coloured pencils are arranged along the axis of the lens in the order of refrangibility. If we designate these foci by the letters $r$, $o$, $y$, $g$, $b$, $i$, $v$, ($r$ being farthest from, and $v$ nearest to, the lens), the distance between $r$ and $v$ is called the "chromatic aberration" of the pencil.

It is found that, by combining $n$ lenses made of $n$ different kinds of glass, according to a certain formula, $n$ different coloured foci may be united in the same point on the axis. When two or more foci are thus united, the lens or combination of lenses is said to be "achromatic," or corrected for chromatic aberration. In such optical instruments as are not intended to be used in photography, it is customary to combine the focus of the green rays with that of the orange; but in photographic lenses the violet rays should be combined with the yellow. *See* "Spectrum."

**Accelerators.** This name is given to any substances used in photographic processes, with a view to shorten the time of exposure, either in the camera or the printing-frame. In the daguerreotype, bromine and chlorine, and especially bromine, exercise a very decided accelerating action, the time of exposure being reduced from minutes to seconds. They require dilution, and therefore must be held in solution, or retained by some solid bodies which easily give them off in vapour. Under whatever names the accelerators used in this process may pass, Woolcott solution, Hungarian solution, chloro-bromide of lime, &c., the active principle is the same in all. When bromine and chlorine are used in their combinations in the calotype and other processes by solutions, they have no such quickening power. It is probable that the pure iodide is not quickened by any addition.

The substances which have been recommended to increase sensitiveness in these processes, may be divided into five classes. Taking iodide of silver as the basis of all quick formulæ, the first class includes the other insoluble salts of silver, such as the bromide, fluoride, &c., which have all in turns been recommended, but without good reason. The fact that these salts give a *visible* image more quickly than the unmixed iodide, has been taken as a proof of greater sensitiveness; but the truth is, the iodide in its best state, though the last to give out an image to the eye, is the first to receive one capable of development by the usual developers. The second class includes the easily decomposed soluble salts of silver, as the nitrate and acetate. The presence of one or more of these is essential to forcible development, and this is their principal use; but they are also said to accelerate, in a slight degree, the action of light itself. The third class is composed of alkalis and basic salts. There can be no doubt that acids, in proportion to their oxidizing properties, restrain or neutralize the chemical action of light in the sensitive film. But beyond neutralizing any acid present in the film, alkalis do not appear to modify the active power but rather to exert their own peculiar action in decomposing the sensitive layer itself. Fourth: organic matter of many kinds is said to accelerate, as honey, sugar of milk, &c. Twenty things have been spoken of, but the best experiments prove that, though they add, by their power of combining with reduced silver, to the visibility of the scarcely apparent picture, and to its final vigour, their action is really to retard, and not accelerate. Still, their presence, in proper proportion, is essential in all negative processes, and in all cases, except the delicate silver film of the collodion positive, where intensity is not required and where organic matter gives drab tones. The last class consists of bodies having a strong desire for more oxygen, and which therefore are, or may be, used as developers. Gallic acid, used in the calotype and in several processess, and iodide of iron, which, when the film is formed, becomes nitrate of iron, are supposed to act as accelerators; but the effect is more to cheat the operator, by carrying on the development simultaneously with the exposure, than to favour the real ictus of the solar ray.

The truth seems to be, that a certain finely divided, semitransparent, pappy and neutral condition of iodide of silver is obtainable, which with a minute excess of nitrate, in our wet processes, gives the most sensitive surface yet discovered. There are certain mechanical conditions, and conditions of temperature, molecular arrangement, proportions, dryness, optical correctness, and easiness and smartness of manipulation, atmospheric pressure, and other influences, which all affect the impressibility of a chemically prepared layer; but these will be better treated under the word "Sensitiveness," *q. v.*

ACETATES. Compounds of acetic acid and oxides, as acetate of silver, which contains acetic acid, silver, and oxygen. They are generally used either to neutralize free nitric acid in N. S. solution, and substitute acetic acid for it, which interferes less injuriously with the production of the image, or else to form a small quantity of acetate of silver in connection with iodide of silver, and thereby add vigour to the impressions. They are formed by dissolving the oxides in the acid, or by adding acetic acid to the proper carbonates, when carbonic acid is driven off with effervescence. The acetate of soda is most convenient.

ACETATE OF AMMÓNIA. $NH_4O, AcO_3$. Kept in aqueous solution, and formed by saturating carbonate of ammonia with acetic acid. It is used like the acetates in general, but is not so suitable as acetate of soda, on account of the nitrate of ammonia formed.

ACETATE OF IRON. There are two acetates of iron, but one, the peracetate, is not used in Photography. The protacetate, or acetate of the protoxide $FeO, AcO_3$ has been used to develope both positives and negatives; and when it is used, 20 grains to the ounce of water, it gives the negatives greater opacity than either the nitrate or sulphate of iron. To make it, mix solution of 139 parts of sulphate of iron and 190 of acetate of lead, or saturate acetic acid by sulphuret of iron.

ACETATE OF LEAD. Sugar of lead of commerce, $PbO, AcO_3 + 3HO = 190$, is sold in crystals of various purity. They are easily purified by re-crystallization. This acetate is produced by digesting litharge, which is oxide of lead, in acetic acid more or less pure, or by exposing plates of lead to fumes of the acid, and dissolving the superficial coating in excess of acid. This and other salts of lead have been added to the N. S. bath, to increase sensitiveness in the collodion process, which they do by setting up partial decomposition and forming basic salts when the bath is old or impure. The film is then so easily reducible that gallic acid will develope it, but the picture will not be clear. Acetate of lead added to the ordinary developers, is also said to increase the density of the negative.

Acetate of Lime, $Ca\ O,\ Ac\ O_3$. Silky acicular prisms which have been added to the developer, but with no well-defined object.

Acetate of Potassa, $Ko\ Ac\ O_3$. Most conveniently preserved in solution. It may be fused, and thus dried, but it is difficult to keep it from deliquescing. It is used to discover the adulteration of citric acid with tartaric; for which purpose add it to the saturated solution, when the tartaric will precipitate as bitartrate of potassa. It should be remembered, that it is formed in minute quantity in iodised collodion if the ether has been kept. This is rather beneficial for negatives, but would lessen the softness and half tone and injure the colour of positives.

Acetate of Silver, $Ag\ O\ Ac\ O_3$. A salt of silver very nearly insoluble in water. The little which water will take up has been found very useful in many negative processes, in excluding the stronger acids, and in furnishing oxide of silver to the organic matter present. It thus favours quickness and vigour. In its action on organic matters, it resembles acetate of lead, which organic matter in many forms decomposes, forming insoluble compounds with the lead in a basic state. The red compound of organic matter and silver, formed in developing, readily attaches to itself the oxide of the decomposing pyrogallo-nitrate, while the bluer image, which is more free from organic matter, is intensified much less. When the acetate is used to saturation in a N. S. bath for collodion negatives, it even produces such excessive deposition of silver as often to veil the entire negative. The smallest quantity in excess of what is necessary to exclude nitric acid will be found sufficient; and as its effect is the same in all the processes, it must not be used for collodion positives, of which the deposit should be as delicate as possible. It always requires the presence of some free acetic acid to prevent its causing fog by its alkalinity. Papers for printing by development, or for sun-printing, may be prepared with it in the same way as citrate or chloride of silver papers are prepared. To procure it in crystals, mix together solution of 137 parts of crystallized acetate of soda and 170 of nitrate of silver, when the crystals are thrown down in a lamellar form.

ACETATE OF SODA. The crystals are $Na\,O, Ac\,O_3, 6\,H\,O = 137$. This is the most convenient acetate for the photographer, and he may make it by saturating common washing soda (carbonate of soda) with acetic acid, or vinegar, and afterwards crystallizing and recrystallizing. It is important also as the source of pure acetic acid.

ACETIC ACID. $Ac\,O_3\,H\,O$; or $C_4\,H_3\,O_3, H\,O = 60$. This acid is used in the developer in the calotype, wax-paper, albumen and collodion processes, to check the spontaneous decomposition and too rapid action of the developing compound, to keep the lights clean, and also to make the developer flow evenly and bite uniformly into the film; it is used in most solutions of N. S. which are intended to excite iodised surfaces on paper, albumen, collodion, and other vehicles, and wherever N. S. is employed it is more or less useful: it is added to gallic acid to lessen its tendency to become mouldy: it has been used as a solvent of xyloidine, to form a film, and is altogether of very extensive and important service in Photography. It is therefore of moment to get it pure and understand its action; and it is of the more importance to know what ends it answers, because it is so generally useful, that it has been recommended in cases where it would be injurious, as in the N. S. bath for collodion positives, where all organic matter, whether acid or otherwise, should be avoided, and where nitric is the proper acid; and also in collodion, which should be preserved in a strictly neutral condition, except in special cases. In order to see the effects it produces, let a person try a collodion negative from a bath made of commercial nitrate of silver, smelling strongly of nitric acid, yet otherwise pure: the resulting image is slowly impressed, feeble in character, and blue in tone, but clear and distinct. The addition of carbonate of soda, until slight alkalinity is produced, makes the picture much redder, much quicker in its formation, with much fog and but little increase of strength. Acetic acid in slight excess of the alkali now shows itself, by restoring clearness entirely, by reproducing slowness and blue tone in a very slight degree, and at the same time by a marked improvement in vigour and beauty: and up to a certain point every drop increases these effects; but it is remarkable how little the sensitiveness is impaired. Its effect in development is best studied by comparing two solutions of N. S. mixed with pyrogallic acid, one containing acetic acid, the other containing none, and observing how much the acid retards the blackening which such solutions undergo.

Other acids exercise an influence similar to, but not identical with, that manifested by acetic.

Acetic acid is formed, under the name of vinegar, by the fermentation of malt liquors, and of wines and spirits: it is also produced in the distillation of wood, when it is called pyroligneous acid. In both cases it is contaminated with organic matters, which colour it, and, in wood vinegar, make it empyreumatic and tarry. If added, in these states, to N. S., the nitrate is discoloured by light, and a black precipitate gradually formed. The pure acid is obtained from these vinegars by saturating them with oxide of lead, carbonate of soda, or similar substances, crystallizing out the pure acetates, and submitting the pure salts to distillation with sulphuric or hydrochloric acid. The acetic is driven off by the stronger acid, a portion of which is apt to go over with it: and when this is the case, the acetic acid, when added to nitrate of silver, will throw down chloride or other salts of silver, and weaken the solution; in development the same cause will weaken or even arrest the appearance of the image. It should therefore be tried with N. S., and with chloride of barium, before use.

The strength of pure acetic acid is very variable, and cannot be determined by its specific gravity. The most constant is the "glacial," which below 40° of temperature becomes solid. When it does not solidify, the only means of knowing its strength is by observing the quantity of crystallized carbonate of soda which is necessary to neutralize it. The dilute acetic acid of the London Pharmacopœia, sold by the druggists, should be such that one fluid ounce saturates 57 grains; the acetic acid fortior, of the Pharmacopœia, or the acid called Beaufoy's, should take 390 grains to the fluid ounce; and the glacial requires 1036 to the ounce, or 129 to the fluid drachm. When pure, any of these may be used by calculating from these numbers the equivalent measures. The numbers 1, 7, and 18, are near enough; but it would be better if a standard acid were used by photographers, easily verified by a standard solution of carbonate of soda.

The disadvantages attending the employment of this acid are worth attention. As used, it is 50 times as dear as citric; it is liquid and bulky, and inconvenient in travelling; its fumes are injurious to the brass work of the apparatus, and unpleasantly strong, and it is of very uncertain strength. It is apt, by solvent action on the size of paper, to render it absorbent, and to cause the picture formed on it to "sink" and lose brilliancy. And it is apt, when present with alcohol, as in the N. S. bath and collodion, to form acetic ether, which injures the transparency and strength of the film, mars the sensitiveness of the plate, and impairs the detail of the image. On these accounts citric acid may possibly supersede it.

ACETIC ETHER. Formed occasionally in ether, by air and light, and injurious in collodion, because it in some degree lessens its transparency and injures its tenacity. Its photographic effect resembles that of acetic acid: and it decomposes the contained iodide.

ACETO-IODIDE OF IRON. Solution of iodide of iron (*q. v.*), with acetic acid added to lessen its injurious effects.

ACETO-NITRATE OF SILVER. A mixture of acetic acid with solution of N. S.: the proportions are given with the processes. When the solutions are concentrated, acetic acid precipitates nitrate of silver, but not when they are dilute, if pure. The reason why the weaker acid, acetic, here displaces the stronger, is the sparing solubility of acetate of silver.

ACHROMATIC. *See* "Aberration."

ACIDS. The uses of acids for special purposes, not actino-chemical, as in the making of pyroxyline, cleaning vessels, removing the size of paper, &c., are specified under the proper heads. Their action in photo-chemistry is what concerns us here. Acids are substances sour to the taste, which change vegetable blues to reds, and which unite with alkalis or other bases in such a way as to neutralize each other's properties. They are of two kinds, chemically considered: oxy-acids or acid oxides, and hydracids or compounds of non-metallic substances, and some compound radicals with hydrogen. The hydracids decompose the soluble silver salts, and therefore completely bar the development of photogenic images, while the decomposition of the acids also prevents our studying their effects, on the formation itself of the image by light. The oxyacids as a class exert in a greater or less degree a retarding effect on the rapidity of formation of the image, which is very remarkable; this is in proportion to their oxidising power. The gallic and pyrogallic acids exert, on the contrary, a powerful reducing or deoxidizing influence, which has made of them our most useful developers. But while gallic has very feeble acid properties, pyrogallic is not strictly an acid at all: and both act more like sugar and other neutral organic substances, than like true acids.

Of the oxyacids, those which produce insoluble salts of silver when present in the film or the N. S. bath, retard the production of an invisible image by the liberation of free nitric acid, and if they are added to the developer, they will partially or entirely annul its action: they are the oxalic, phosphoric, sulphurous, and others. Those which give salts of silver more or less soluble, vary in their effects according to their oxidising power. The vegetable acids, as acetic, citric, malic, and tartaric, are the lowest in the scale; the mineral acids, perchloric, sulphuric, &c., are next, and nitric is the strongest. One twentieth of a minim of nitric acid in the N. S. bath, will perceptibly injure its sensibility, and will have a still more decided effect in weakening the developed image, and keeping the reduced silver pure and free from organic matter. The organic acids, however, affect the sensitiveness but little, while they give colour and intensity in a considerable degree. These effects are most strongly perceived when the acids are added to the exciting bath; but a larger quantity added to the developing solutions have a corresponding influence. The difference observed in various kinds of collodion, ether, paper and its sizing, and other material, may be always traced to the presence of acid bodies. In all negative processes, it will be judged essential, in consequence of these established reactions, to remove every trace of nitric acid, and make use of a vegetable acid to preserve clearness. The acetic, malic, and succinic, act much alike, but the acetic is rather the best negative acid; and all may be used in tolerable quantities without very rapid difference in the results. Citric acid must be used much more carefully, for while even 5 or 6 minims of acetic may be added to each fl. ounce of the N. S. bath without causing vastly more change in it than 1 minim, citric must be added by proportion at least 20 times as small, and each addition will increase the effect perceptibly.

The consequences of employing acids in the fixing, toning and other solutions, with the effects of acids in reacting on finished photographs, will be discussed under the proper words.

Actinism. (Greek ακτιν, a ray). A ray of light, whether proceeding from a heavenly or terrestrial body, is found, in general, to possess three properties, viz., the luminous, the calorific, and the actinic. The actinic is that chemical property of the ray, which produces important chemical changes in many substances submitted to its action, and on which the whole art of photography is founded. When a ray of light is decomposed by refraction through a prism into its constituent colours, it is found that actinism exists chiefly among the violet, and scarcely at all among the yellow rays. Hence the importance of combining the violet or actinic focus of a photographic lens with the yellow or luminous focus: for the actinic rays produce the photographic picture, while the luminous rays render the image visible on the focussing screen.

Actinograph. A name given by Sir John Herschel to his "self-registering photometer."

Adhesion, Attraction of. A remarkable instance of this kind of attraction occurs in the intimate union which takes place when a collodion picture film is transferred to gutta percha, leather, paper, waxed cloth, and other surfaces. The collodion appears to enter into the pores of the material in such a way that it cannot be rubbed up, and it is very difficult to detect its presence. Air adheres to paper and metal surfaces so closely, as often to interfere with their being easily coated or wetted.

Aerial Perspective. The earth's atmosphere contains, beside air, aqueous and other vapours partially condensed, and also solid particles which scatter light, and thus render themselves more or less visible. The air is of a blue colour. Hence it follows that objects are viewed through a medium which imparts to them more or less of its own blue local tint, according to their distance, and covers them with more or less of indistinctness. These effects are called "aerial perspective," and it is erroneous to suppose that photography cannot faithfully reproduce them. On the contrary, it is frequently found to exaggerate them, and the reproach under which it has lain, of representing nature like a hard and distinct map upon one plane, has originated in the timid practice of photographers, in avoiding the very class of objects which they should aspire to copy, and in confining their practice out of doors to those cases in which the unusual clearness and distinctness of distant objects seemed to invite the camera. But every day, as the real capabilities of landscape photography are better understood, the photographer should become more ambitious, and seek for those very studies, which, in the infancy of the art, were esteemed impracticable. Skies, moving water, animate objects, mists, haze and all atmospheric effects, should now engage his earnest attention. It will be observed, that aerial perspective is increased in proportion as the vaporous and other particles in the atmosphere are more strongly illuminated, and is therefore greatest in the direction of the source of light.

Æsculine. A white powder, obtained by deposition from a strong alcoholic solution of horse-chesnut bark. A mere trace, dissolved in spring water, communicates to it a blue opalescence; and the effects of its solutions on luminous and actinic rays are instructive and curious. It has the property of rendering the chemical rays visible; and this has been taken advantage of where there is a great distance between the chemical and visual foci of a lens, to find the place of the chemical image. Other bodies have the like properties. *See* "Fluorescence."

Affinity. That power of attraction which causes dissimilar chemical substances to combine. It is wrong to reason as if the chemistry of photographic operations was always in accordance with the usual affinities of bodies, because light, like electricity, will overcome, and even sometimes reverse the order of the strongest of them.

Agate Burnisher. Positive prints on plain paper are sometimes "mealy" and deficient in vigour. In such cases, it is thought by some persons an improvement to impart a smoothness and glaze to the surface of the paper by rubbing it all over with a polished piece of agate. In this operation the paper should be laid face upwards on a slab of plate glass, marble, or other hard polished substance.

Air-pump Process. A process in which, the paper being prepared in vacuo, was found to be more readily impregnated with the solutions employed, but which was not sufficiently practical to be generally adopted.

Albumen. This, in photography, means the white of an egg, which is a pure form of it. It is used on paper for both negatives and positives, and on glass for negatives and dia-positives, as a vehicle for the sensitive silver salts. For negatives on paper, albumen is not often used, for the same reason that collodion negatives are seldom transferred to paper; that is, because the advantages of the albumen and collodion are then partly lost. It is not so sensitive as collodion, from its more horny nature and its being dry; but, for the same reasons, it will keep longer when sensitized. From its entering into combination with nitrate of silver, it gives a blacker image than collodion or gelatine, and one more inclined to become yellow: the image, from its organic character, is also more soluble in hypo and other solvents of the silver salts, and is therefore reddened and weakened more in fixing. The blackness of the image makes it the best material for transparencies on glass; but its tendency in negatives is to give hard cutting pictures, and it is more troublesome than collodion in the manipulation. When applied to paper for printing, it gives the power of rendering the details of the negative with extreme sharpness and great transparency in the shadows; but the smoothness is scarcely artistic; and when the glazed surface is perceived by the eye, it becomes offensive. That veil which sometimes covers pictures on plain paper is never seen on albumen; but, on the other hand, plain paper gives good tones with greater ease and certainty.

Albumen retards the action in the camera or printing-frame, but increases the beauty and vigour of the image. It combines, like other forms of organic matter, with bases and basic salts, which are then called albuminates. Thus, in the paper processes it unites with and is coagulated and rendered insoluble by the N. S., and the surface becomes a layer of chloride and albuminate of silver, which does not require any application of heat, as some suppose. It is this combination chemically with the silver salt which reddens the tone of the reduced silver; for those organic matters which have no combining have also no colorific power.

Albumen is, before coagulation, soluble in water, and is most frequently more or less diluted with water in all the processes, to increase its fluidity. The entire destruction of the minute membranous cells in which it exists in the egg, either by mechanical violence, as in whipping it, or by the addition of a small portion of alkali, which dissolves them, is necessary to the obtaining of a uniformly clean layer, and the alkalinity may be neutralized after the application of it, to the glass or paper, by acetic acid in the exciting solution.

ALBUMEN PROCESSES. The albumen processes now in use are as follow :—

1st. The positive printing process on albumenized paper.
2nd. The negative albumen process on glass.
3rd. The dia-positive process on albumenized glass (*see* "Dia-positive").

### I. ALBUMENIZED-PAPER PRINTING PROCESSES.

There are two processes to be described under this head—a sun-printing process and a development-printing process.

### 1. *The Sun-printing Process.*

*To prepare the Albumen.*—Take a sufficient number of fresh-laid fowls' eggs, each of which contains nearly an ounce of albumen. Break each egg on the edge of a cup, and collect the white, or albumen, carefully rejecting the germ and yelk. Put all these whites together into a large basin, and add an equal quantity of clean rain water, and 6 grains of common salt to every fluid ounce of the mixture. Then beat the whole up to a very stiff froth with a bunch of quills. Allow it to settle till the next day, and decant the liquid, which is then fit for use.

The albumen, before being beaten up, is contained in small membranous cells, which are broken in the process of beating, and the albumen liberated. This membranous tissue is highly soluble in an alkali, and the addition of a few drops of ammonia to the albumen has been recommended by M. Davanne, as a means of rendering it more fluid. The ammonia, being volatile, mostly escapes from the albumenized paper while drying.

The proportion of water to the albumen may be varied according to the nature of the subject to be printed. More water gives less glaze, and *vice-versa.*

*To Albumenize the Paper.*—Filter the salted albumen through two folds of fine muslin, previously damped, into a shallow bath, to the depth of at least a quarter of an inch. Turn back a corner of the paper, and place the face of it on the liquid, leaving it in contact for about a minute. Then hang it up to dry, by pinning the dry corner to the edge of a shelf. Unless the membranous cells which contain the albumen are thoroughly broken up, it is very liable in drying to form streaks and waves on the paper.

The best paper to employ is that which has the smoothest and finest surface. The paper manufactured in France by Messrs. Marion, and Canson Frères, is generally preferred.

*To excite the Paper.*—Float the albumenized side on a 60 grain N. S. bath, for two minutes, and hang it up to dry in the dark.

This is the full strength of the bath. A weak negative requires a strong silver bath, and a short exposure; a strong negative a weaker silver bath, and a longer exposure.

*The Exposure to Light.*—Expose in the pressure-frame either to sunshine or diffused light (the latter is best for feeble negatives abounding in half-tone), until the print is somewhat darker than you wish it to be ultimately.

*To fix and tone the Print.*—Immerse it at once in a fixing and toning bath made thus: Dissolve eight ounces of hypo-sulphite of soda in eight ounces of clean rain water. In a separate vessel dissolve eight grains of chloride of gold in eight ounces of distilled water. Add the latter solution to the former in small quantities at a time, stirring well after each addition. The mixture will assume a milky colour. This is the fixing and toning bath. The print is to remain in it about half an hour, or until the desired tint is produced.

The fixing and toning bath may be used several times, and several prints may be placed in it at a time; but it should be thrown away as soon as it becomes dark-coloured, or tones feebly.

*To remove the redundant Chemicals from the Paper.*—This is effected by copious washing, and long soaking in water changed several times. Some persons use warm, or even boiling water, in the final operation. The print is then pressed between clean cloths, and hung up to dry. The chemistry of the process is now completed.

The edges should be trimmed, and the print mounted as soon as possible, as handling it with the fingers is very likely to produce faded spots and stains. *See* "Mounting."

### 2. *The development-printing Process.*

The particulars of this process will be found under the head of "Printing by Development." The paper must be albumenized in the same way as for sun-printing, and the remaining operations are identical with those for printing by development on plain paper. It may be as well, however, in this process to omit the ammonia in the albumen bath, as free alkali in the paper is likely to occasion discoloration in the process of development.

## II. ALBUMEN-NEGATIVE PROCESS ON GLASS.

*To prepare the Albumen.*—Collect in a basin the whites of a number of eggs, carefully separating the germ, and all portions of yelk. To each ounce of this albumen add one dram of distilled water, in which is dissolved 6 grains of iodide of potassium; also to every 5 ounces of the mixture add one drop of ammonia. Beat the whole to a stiff froth with a bunch of quills, and allow the liquid to settle till the following day.

*To albumenize the Plate.*—The glass plate must first be cleaned very thoroughly, and polished with a cambric handkerchief just before use. (On this head see the article "Cleaning.") Attach to the under side of it a gutta percha plate-holder, having a wooden handle a foot long. Then breathe on the plate, and, holding it horizontally in the left hand, pour upon the centre of it a sufficient quantity of the albumen from the basin to cover it, allowing the albumen to filter through an opening in the dry froth or crust. Make the albumen flow backwards and forwards over the plate three or four times, and then let it all run off into a separate basin, from which it must be carefully filtered before being used a second time. In coating the plate, be particularly careful to prevent air-bubbles from forming upon it. Next, take the handle of the plate-holder between your hands, and, with the plate in a vertical position, spin it round quickly for a minute or so, in order to drive the albumen to the edges by centrifugal force. This done, remove the excess of albumen from the edges by means of a pipette (*see* "Pipette"), and dry the plate before a clear fire, keeping it rotating all the time by means of the handle, as before directed. When dry it is ready for the next operation. Albumenized plates may be put away in a plate-box, and kept for a considerable time without deterioration in a dry place. Care must be taken, in the operation of albumenizing the plate, that no particles of dust adhere to it.

*To excite the Plate.*—Place it on a dipper, and immerse it quickly and without hesitation in a vertical bath of aceto-nitrate of silver, made thus: Distilled water 1 ounce, nitrate of silver 50 grains, glacial acetic acid 1 dram. Leave it in the bath for a couple of minutes, then wash it well in clean water, and lastly in distilled water, and set it up to dry. When dry put it away in the plate-box until ready for use in the camera. It may be preserved in a sensitive state for several days. Some persons add a few drops of a solution of iodide of potassium to a new nitrate bath, and filter it on the following day, in order to saturate it with iodide of silver. When this is done a new bath is not so liable to attack the iodide of silver in the film.

*The Exposure.*—Albumenized plates, from which the excess of free nitrate of silver has been removed by washing, are, whether used in a dry or wet state, extremely insensitive to light; but, when only slightly washed, exposed at once, and developed with a strong developer, a much shorter exposure is sufficient. This should be timed solely with reference to the shadows, the lights being left to take care of themselves. When the camera is properly constructed, so as to prevent stray light from falling on the plate, it is hardly possible to over-expose a dry, washed, albumenized plate.

*To develop the Image.*—First, immerse the plate in distilled water; then place it in a levelling-stand, and pour over it a saturated solution of gallic acid, to which a few drops of aceto-nitrate of silver have been added. The development occupies about twenty minutes.

*To fix the Picture.*—Wash the plate in rain water, and pour over it a nearly saturated solution of hyposulphite of soda. This will quickly remove the yellow iodide of silver from the film. Then wash the plate well under a tap, and dry it before the fire.

The negative may be varnished with any good varnish, (*see* "Varnish,") but this is not always done.

### III. ALBUMEN—DIA-POSITIVE PROCESS ON GLASS.

Positives obtained by this process are intended to be viewed by transmitted light. The manipulation is so nearly identical with that of the albumen-negative process, described in the foregoing article, that it is only necessary to point out the difference between them.

The negative to be copied is placed either in a copying camera, (*see* "Copying Camera,") or in direct contact with the sensitive plate in a pressure-frame. In the latter case the plate must be used dry, and the exposure to diffused daylight, or artificial light, only occupies a few seconds; in the former case, the plate may be either dry or wet, and the exposure is considerably longer. The wet process is the least troublesome, and yields the best results, because the operations of exciting, exposing, and developing, may then succeed each other at once, and less time is allowed for a combination to take place between the silver and albumen, which causes the lights of the picture to assume a yellow tint. The development is also a much quicker operation in the wet process, more nitrate of silver being allowed to remain on the plate, and for this reason also the lights are less likely to assume a yellow tint.

The difference between this and the negative process consists chiefly in the employment of a gold toning-bath, in order to vary and improve the tint of the finished picture. Thus, before fixing the picture, pour over it a little of the following solution:—1 grain of sel d'or, 20 drops of hydrochloric acid, and two ounces of distilled water. Allow this to remain on the plate a short time, until the shadows assume a purple tint; then wash it off, and fix as before.

Dia-positives on glass should be viewed with the plain side of the glass next the eye; and against the film the rough side of a finely ground glass should be placed, the two glasses being bound together at the edges with a strip of tape or paper pasted over them. In this way the print is protected from injury, and has a proper semi-transparent background.

The chief use of this process is for printing transparent slides for the stereoscope. In this operation it must be remembered that the picture taken from the right station must be viewed by the right eye, and *vice-versâ;* and also that the objects in the view must not be reversed as regards right and left. It may therefore be necessary to place the negative in the copying frame with its back to the lens. Matters of this kind must be carefully considered by the operator; and his ingenuity will suggest the proper way of proceeding in every case. No general rules need be laid down in this place.

ALBUMINATE OF BARYTA. Strictly speaking, this should be a salt of albuminic acid and oxide of barium. It is said to be formed when albumen papers are salted with chloride of barium; but the compounds formed by albumen and other such substances with bases and basic salts, require to be further examined. An inquiry into their exact composition would throw much light on photographic chemistry.

ALBUMINATE OF LIME. A compound analogous to the preceding.

ALBUMINATE OF SILVER. The white precipitate which falls when albumen is added to a solution of nitrate of silver is called by this name. It would imply that it is a neutral salt of albuminic acid and protoxide of silver; but there is not sufficient proof that the silver exists in it in the state of protoxide in combination with a normal acid body. Albumen is alkaline, and an animal substance of a very complex nature, containing even inorganic salts essential to its constitution. It therefore undergoes decomposition in contact with nitrate of silver, and all that can be said is, that the precipitate contains organic matter and some oxide of silver, of which the former acts the part of an acid, and the latter of a base.

ALBUMINATE OF SUBOXIDE OF SILVER. The red compound formed when light reddens the albuminate of silver, and containing less oxygen than it.

ALCOHATES. Crystallized salts, which include alcohol in their composition, in the place of water of crystallization. Without forming a true alcohate, alcohol sometimes modifies the forms of crystals deposited from its solution, as in the case of the collodion iodizing solution, made with nearly absolute alcohol, saturated with iodide of potassium. Instead of pure cubes, the forms are then more or less acicular, shooting in directions at right angles to one another.

ALCOHOL. On this important substance the remarks interesting to a photographer will be, its special use in the collodion process, its effect as organic matter on the photogenic image, and its assistance in developing. Pure alcohol as organic matter is nearly inert in photolytic processes, but when decomposed or oxidized with ether, by long use in the exciting bath, organic principles are formed which act like strong acids, and their effect is too injurious to be attributed to the formation of acetic acid. Such a bath, if evaporated to dryness, will show that the organic matter is in combination with the nitrate of silver; for on fusion the salt froths violently as long as any organic matter is undecomposed. Added to the collodion developers, it has been found very beneficial in making them flow evenly and quickly over the plate; but it has not been tried as it deserves in the development of paper negatives. When it is added to the solution of gallic acid, it is easy from its greater solvent power to get the proper strength, and there is less tendency to the formation of crystals and stains, than when concentrated aqueous solutions are employed. The spirit has greater power also of penetrating into the wax and size; but this property, though useful in negatives, forbids its use in paper positives, where surface vigour is requisite.

The most important use of alcohol is in collodion, and attention must be paid to its strength and purity.

Absolute alcohol of S. G. 796 or 75·25 above proof, is very difficult to keep in use, because, from its strong attraction for water, it rapidly absorbs it from the air. But this is not necessary to the photographer. Absolute alcohol is not the best for collodion, either as respects the physical or chemical qualities of the article. When iodide of potassium (the most generally useful iodide) is used in collodion, it is so little soluble in alcohol + ether, that if the strongest spirits are employed, the iodide is precipitated in the film before going into the N. S. bath. The consequence is seen both in the appearance of the film before going into the camera, and in the developed picture. The film before exposure appears by transmitted light semi-opaque, bluish in colour, and by reflection dim yellow, like bad iodized paper, because the salt, as in paper, is not in solution when the nitrate attacks it, but when the iodide is properly formed in a film containing sufficient water, it remains more or less in a state of semi-solution, as in jelly, and the colour is bright yellow, perfectly transparent by transmitted light, and of a blue cast by reflection. The same want of transparency is observed with the same colours, in whatever way the iodide of potassium becomes excessive. In the picture the result is a sensitiveness scarcely superior to that of albumen on glass, and very feeble reduction. Alcohol of S. G. 845 is very good for mixing with ether in making the plain collodion, and ·810 in the iodizing solution. The water being in the ethereal mixture counteracts its tendency to precipitate the salt from the iodizer. The strength of pure alcohol is obtained by its specific gravity; as it occurs in commerce it is generally from S. G. 820 to 850. What is called "proof spirit" is alcohol of S. G. 920. By spirit 60 degrees over proof, a strength which is very commonly sold, is understood a spirit 100 measures of which, added to 60 measures of water, will form proof spirit. Its S. G. is 830. Spirit of 50 degrees over proof needs only 50 measures of water to 100 of spirit to bring it down to proof, and so on. In the French formulæ, spirit of so many *degrees* is often spoken of. This refers to Baumé's hydrometer, for comparisons of which with the S. G. and with proof spirit, *see* "Tables of Weights and Measures."

With respect to the purity of alcohol, it is necessary to be very careful in collodion for the positive process. All alcohol is apt to contain organic matter, fusil oil, grain oil, &c., which, though in small quantities, will exercise a more decided photographic effect, prejudicial or otherwise, than a large quantity of the alcohol itself. In negative processes these impurities may be beneficial, but not where pure metallic silver is to be produced. In all cases alcohol from the grape seems preferable to that from grain or roots. The last, when not purified, often leaves on distillation, a red residue in the retort, very offensive to the smell. The purity of alcohol is a much more important matter than its strength.

ALDEHYDE. (Al. short for alcohol, dehyde for dehydrogenatus.) Alcohol, from which 2 atoms of hydrogen are removed. It is found sometimes in acetic acid, and it probably exists in minute quantities in ether and alcohol, which from age and decomposition in the N. S. bath have been partially oxidized. It is a very powerfully deoxidizing agent, and has been used to improve the tone of collodion positive pictures, by removing organic matter from the picture, and reducing it more completely to the metallic state.

ALKALINE COLLODION. N. S. bath, toning bath, &c. *See* "Collodion," &c.

ALKALIS. Certain oxides of metals and compound radicals which are of an acrid taste, which change vegetable blues to greens, and whose properties are masked or neutralized by their union with acids. Their actinic effects are opposed also to those of the acids. As acids, when free in the sensitive surfaces, have a retarding power over the formation of the photogenic image, so alkalis, by neutralizing the acid, appear to possess a quickening influence; but when an excess of alkali is present, it precipitates oxide of silver by its proper force, without the access of light. Acids preserve the lights of photographs clean, under the action of the developer, by preventing spontaneous reduction of the gallo-nitrate, &c., and often by obliterating the faint impression of light up to a certain point; alkalis produce universal blackening of the silver surface. In the hyposulphite bath, acids liberate sulphur, and produce changes which blacken the prints immersed in it, and then make them turn yellow and fade; alkalis favour the stability of the bath and of the prints, but redden without weakening it. On the contrary, acids check the toning power of sel d'or and increase its stability, while alkalis decompose and render it violent.

Potassa and soda are often called alkalis proper and fixed alkalis, because they are bodies which possess alkaline properties in the highest degree, and because they are not apt to fly off like ammonia, which has received the name of volatile alkali. But metallic protoxides in general have the alkaline quality of neutralizing acids, and when soluble, of affecting vegetable colours. A N. S. bath may have its free acid neutralized as well by oxide of silver as by potassa.

Alkaline salts, carbonates, chlorides, &c., are the carbonates, &c., of the alkali. In some of these, as in nitrate of soda, the alkali is completly neutralized by the acid, but in the carbonates and others there still remains some alkaline reaction. The most generally useful alkaline substance for the photographer is carbonate of soda, and will be found to answer in almost all cases where acids are to be got rid of.

Allotropic, (ἄλλος another, τροπος form). When the same substance exists in two or more forms having different properties, but still chemically the same, as albumen in the liquid and coagulated state, the unusual form is said to be allotropic. Light produces allotropic forms in some bodies, and certain temperatures do the same with others. Those who suppose the action of light to consist in a molecular disturbance of the sensitive surface, imagine it by actinism to produce these allotropic conditions of bodies.

Alternation of Luminous Action. It is asserted by some that there is a periodical recurrence of two opposite effects in the action of light; that the first impression is negative as to light and shade, then positive and afterwards negative again, and so on at regular intervals. Light undoubtedly, under certain conditions, appears to exercise both a negative and positive effect as to reduction, but in some instances we know the conditions for the two effects are different, and may be varied to produce either result at will; and this is probably the case always, though the difference is so subtle as to escape our observation. That the effects recur, or are repeated regularly, is not established by any experiments. *See* "Reverse Action of Light."

**ALUM.** $Ko, So_3; AL_2, O_3, 3 So_3; 24 Ho$. A double sulphate of potassa and alumina, having an acid reaction. It has been recommended for the removal of hyposulphite of soda from paper pictures, without abstracting the size. If the acidity of alum has no injurious effect on the print, which is doubtful, it may be used with advantage. It is often used with resin in sizing papers, and that will account for the superior cleanness of some papers under development.

**AMBER.** A fossil resin found on some sea coasts, and also in seams of coal; it is used in making amber varnish. *See* "Varnish."

**AMBROTYPE.** Collodion positives are sometimes called "Ambrotypes," in America.

**AMETHYST.** This and other precious stones, as the opal, are found, under prolonged exposure to light, to lose their sparkle.

**AMMONIA.** $N H_4O$, or $N H_3$. This gas is always used by the photographer in aqueous solution, called "liquid ammonia." It dissolves chloride of silver, but not iodide; hence it is used to separate one from the other, and also to fix prints on chloride papers. It is applied after bichloride of mercury, to intensify weak pictures, and it is used in the preparation of ammoniacal oxide and ammonia-nitrate of silver, and has been added to collodion to render it more sensitive; but it decomposes the pyroxyline, rendering it rotten, and the collodion thin, and also gradually impairs the condition of the N. S. bath. It is useful in preparing positive prints for toning with sel d'or, and, as a strong detergent, is often made into a paste with tripoli, for cleaning glass plates. As far as possible its presence in any sensitive surface is to be avoided, except where nitric acid may be present also in excess.

Gaseous ammonia is evolved when two parts of dry quicklime are mixed with one part of chloride of ammonium in a retort, and a gentle heat applied. Water takes up 6 or 700 hundred times its volume of this gas, and the saturated solution is of the S. G. 875. The druggists' liquor ammoniæ of the London Pharmacopœia is S. G. 960. The liquor am. fortior is S. G. 882, and is reduced to the other, by adding 2 ounces water to each fl. ounce. Of these three solutions the first contains 33½ per cent. by weight of ammonia, the second only 10, the third nearly 30. The solution absorbs carbonic acid from the air, with the formation of carbonate of ammonia.

AMMONIA, ACETATE OF, AURATE OF AUREOLE, &c. *See* "Acetate," &c.

AMMONIACAL OXIDE OF SILVER, sometimes called AMMONIURET OF SILVER. It is a solution of oxide of silver in liquid ammonia, (*see* "Ammonia,") and is used in printing. *See* "Printing."

AMMONIO-CHROMATE OF COPPER. Chromate of copper dissolved in liquid ammonia. The solution is green, and papers prepared with it are bleached by light. When the shadows, under a negative, are sufficiently whitened, either copper or silver compounds may be reduced upon them by developing with carbonate of soda or nitrate of silver.

AMMONIO-CITRATE OF IRON. This neutral double salt of citrate of peroxide of iron, and citrate of ammonia, dissolved in water, and mixed with solution of ferro-cyanide of potassium, gives a purple solution nearly black. Papers prepared with this are bleached in the light, but darken again in the dark. Salts of cyanogen, and salts of iron, are both subject to actinolyitc action; but the iron is here the one attacked. This paper may be used to take evanescent pictures of many objects successively. The ammonio-citrate of iron itself, is a beautiful pharmaceutical preparation. It is a salt of the peroxide of iron, which is partially reduced by the chemical rays to protoxide. Papers prepared with a solution of it, change by insolation from a bright yellow to an ochrey grey, and may be developed before the picture becomes visible by ferridcyanide of potassium, (red prussiate of potash), which proves the reduction to the state of protoxide, by the formation of prussian blue. It is known to all photographers that the protosalts of iron, as the protonitrate, the protacetate, the protocitrate, &c. are developers, and their formation by light is a curious instance in which the usual order of operations in taking a picture is reversed. First, the paper is prepared with an iron persalt, which, by solar action, becomes a developer in certain parts only of the paper, and the picture is then produced by the action of this local developer on any salts applied uniformly to the paper which it is capable of deoxidizing. Bichromate of potass, nitrate of silver, and many others may be thus applied, and appear to develope the print themselves, but in truth only supply material to the invisible developer, which pre-existed on the surface.

AMMONIO-NITRATE OF SILVER. Chemists give this name to a white substance composed of 100 parts of nitrate of silver, and 29½ of ammonia; but in photography it is either a solution containing oxide of silver, nitrate of ammonia, and ammonia, or oxide of silver and nitrate of ammonia alone. It is used in "printing," *q. v.*

AMMONIO-TARTRATE OF IRON. A compound behaving like the ammonio-citrate.

AMMONIUM; $N H_4$. A hypothetical substance not yet isolated.

AMMONIUM, CHLORIDE OF, PHOSPHURET OF, &c. *See* "Chloride," &c.

AMPHITYPE. (Greek, *αμφὶ*, on both sides). A process discovered some years ago by Sir John Herschell, in which light produces either a positive or negative. A sheet of paper is first prepared with a solution, either of ferro-tartrate, or ferro-citrate of protoxide, or peroxide of mercury, and then with a solution of ammonio-tartrate, or ammonio-citrate of iron, the latter solution being in excess. On exposure to light in the camera, a negative is produced of more or less vigour, and of a very rich brown tint when the paper contains a salt of lead. It gradually fades in the dark, but may be restored as a black positive, by immersing it in a solution of nitrate of mercury, and ironing it with a very hot iron.

ANGULAR APERTURE. The angular aperture of a lens is the angle which its diameter subtends at its principal focus.

ANHYDROUS. Many substances in chemistry have such a strong affinity for one or more atoms of water, that they seem incapable of existing without these atoms, or a base of some kind as a substitute. When the water is replaced by a base, or is otherwise entirely removed, the substance is anhydrous, (α not, and ὕδωρ water). Glacial acetic acid contains one atom of water, which, when it combines with oxides or other bases, it liberates.

ANIMAL CHARCOAL. The product obtained by the carbonization of muscle, horn, blood, bones, and other animal matters. It is distinguished from vegetable charcoal by its lustre and sponginess. It is used in photography to remove colour and organic impurities from solutions of nitrate of silver, &c. In commerce it contains phosphates and other salts derived from the animal organism, which, when it is added to N. S. solutions, produce a yellow precipitate of phosphate of silver, and this often to such a degree as greatly to weaken the solution. Nitrate baths have been so weakened by it as to cause the iodide of silver entirely to peel off the plate on attempting to excite it. When purified it often contains hydrochloric acid, which precipitates white chloride of silver. It is called in trade ivory black, bone black, &c., and its impurities are always such, that it is better to employ kaolin.

ANIMAL OIL OF DIPPEL. Has been employed as a solvent of bitumen in M. Niepce's processes. *See* "Bitumen." It is rectified oil of hartshorn, and is itself discoloured by solar light.

ANIMAL SUBSTANCES. The animal matters used in photography are gelatine, albumen, gluten, isinglass, and a few others; they are of service both in forming transparent films, and in themselves combining with silver compounds for the production of images. They are substances with which English papers are sized, and hence pictures on English papers are redder in tone than those on the French and German papers sized with starch. *See* "Organic Matter."

APERTURE. *See* "Lens."

APLANATIC. (Greek, πλαναω to cause to wander). In optics, a lens is said to be aplanatic when it has been corrected for spherical aberration.

APPARENT DIRECTION, DISTANCE AND MAGNITUDE. *See* "Stereoscope."

APPLICATION OF CHEMICAL SUBSTANCES TO PAPER AND OTHER SURFACES. This part of photographic manipulation is one of some importance. The production of uniform films by means of vapours is very simple in execution, but it is doubtful in such cases as the daguerréotype, what is the exact composition of the substances formed. Their continual change of colour is an evidence that they are not definite, not to speak of the amazing difference in their photographic properties. In the production of films of true chemical compounds, if pure salts are to be examined, it is necessary they should be precipitated on glass or other surfaces absolutely inert, for if collodion or other matters be present, no argument can be built upon the assumption of their purity. The pure salts themselves must settle upon the glass and be carefully drained, or experiments may be tried upon them while still in suspension. In other cases, sensitive surfaces are formed directly on paper or gelatinous beds by immersion and floating, by glass rod, by spatula, or by brush. When a cream of the substance is to be applied, the spatula must be used, but the plan is only useful in experiments, as the coating is too uneven for the production of fine results. When a little variation in the quantity or strength of the salts is of no moment, floating and immersion may be resorted to, but these plans quickly lessen the quantity of the solution, and when double decomposition occurs, they also soon reduce its strength, and the prepared films are not constant in their actinic properties. The glass rod and brush are the most exact methods of manipulation, and of these the rod is more correct, the brush more convenient. All photographic formulæ should, if possible, be so constructed that the solutions, paper, &c., should continue unvarying.

Aqua Fortis. Nitric acid.

Aqua Regia. Nitro-hydrochloric acid, *q. v.*

Aqueous Ammonia. Liquid ammonia. *See* "Ammonia."

Aqueous Chlorine. Solution of chlorine gas in water.

Aqueous Nitric Acid. The strongest nitric acid contains an atom of water; but in combination, as in nitrate of silver, it is anhydrous.

Areometer. An instrument much used on the continent for measuring the specific gravities of liquids.

Argento-cyanide of Potassium. A solution of cyanide of silver in cyanide of potassium, used in electroplating and in silvering copperplates for the daguerréotype.

ARSENIC SULPHURET OF COBALT. A compound of arseniuret and sulphuret of cobalt, which is partly decomposed by light.

ARSENIOUS ACID. As $O_3$. This has been tried instead of acetic in the developer, but it prevents blackening for a time only.

ARTIFICIAL LIGHT. The light produced by electricity and combustion is found to be more or less actinic. The photographer may therefore avail himself of this property of various artificial kinds of light, to work at night, or when diffused daylight is too feeble for his purpose. Of all kinds of artificial light, that produced by electricity appears to be the most actinic. The most convenient mode of employing electric light is by means of a galvanic battery, having wires tipped with charcoal points brought into close proximity. The light produced in this way is extremely intense and highly actinic. A burning jet of the mixed gases oxygen and hydrogen, brought to bear upon a ball of lime, is perhaps the next in intensity. The oxy-calcium light, produced by passing a jet of oxygen into the flame of a spirit lamp, and causing it to act upon a lime ball, is also very intense. Common gas burners and argand lamps, aided by a reflector, may also be used by the photographer for certain purposes, and even the light of a tallow candle is sometimes dangerously actinic. Various chemical compositions have been employed for producing, by their rapid combustion, an intense actinic light, acting during a few seconds only. By mixing together 4 parts of chlorate of potass, 2 parts of sulphur, and 1 part of sugar, all in fine powder, and igniting it, a very intense light is produced.

The effect of any artificial light is greatly increased by placing it in the focus of a parabolic reflector.

ARTIFICIAL PARCHMENT. If a sheet of blotting-paper is immersed for a second or two in a mixture of 2 parts sulphuric acid and 1 part water, and then rinsed in several changes of water, an extraordinary change is produced in it, apparently without altering its chemical composition. It becomes tough, strong, semi-transparent, and very difficult to tear, even when wet; resembling in appearance common parchment, and possessing many of its properties. When dry it contracts and becomes brittle and easily cracked. If a piece of calico or linen is submitted to the same treatment, it is similarly acted on and rendered waterproof, and semi-transparent while wet. On drying, however, it contracts and cracks like the blotting-paper.

Artificial parchment has been used with some success in making a pyroxyline which is said to give a fluid and good collodion. No other use has yet been made of it in photography.

ASPHALTUM. This is an indurated bitumen, found in Judea, the West Indies, South America, and other places. It varies in quality, but may be purified by boiling it in water, when the pure asphalt melts and floats upon the surface, while the impurities subside. It is the basis of most black varnishes, being dissolved in naphtha, turpentine, &c., with oil, gutta percha, india-rubber, &c., to give it toughness. *See* "Varnish."

ASTRO-PHOTOGRAPHY. A convenient name for the application of photography to the delineation of solar spots, the moon's disc, the planets and constellations.

ATOM. This word is applied by those who adopt the atomic theory, to the minute ultimate particles beyond which they suppose matter cannot be divided. In chemistry it is often synonymous with "chemical equivalent," *q. v.*

ATOMIC THEORY. The theory which supposes all bodies to be composed of indivisible particles, every substance being an aggregate of atoms all of the same form and weight.

AURATE OF AMMONIA. This may be formed if ammonia is added to a strong solution of chloride of gold, with a view to neutralize the acid. It is fulminating gold, and must be dealt with cautiously.

AVOIRDUPOIS WEIGHT. *See* "Tables of Weights and Measures" at the end of the volume.

AXIS. A line with respect to which a lens or piece of apparatus has its parts symmetrically situated.

AZOTATES. The French name for nitrates.

AZOTE. Nitrogen.

AZOTIC ACID. Nitric Acid.

**Background.** In taking portraits, it is generally necessary to place a background behind the sitter. This is made by stretching a sheet of canvas, previously wetted, on a deal frame, and painting it of an appropriate colour in distemper. The canvas should be in one piece, and not less than eight feet square. When nailed on to the edges of the frame in a wet state, it contracts on drying, and becomes perfectly flat and tight. The water in which it is wetted should be strongly sized: it will then be ready for painting on, when dry. Oil colour is objectionable, from its imparting a glaze to the surface. The colour should be perfectly dead and opaque, and of a neutral tint, made by mixing black, white, and red; in the proportion which is thought most desirable. As a general rule, the background should be a shade darker than the middle tints of the picture, but in vignetted portraits it may be a shade lighter. A shaded background is a great improvement to a portrait when judiciously done, but it involves so much extra trouble, that few professional portraitists have attempted it, as a rule. Painted backgrounds in which peeps of distant scenery, bits of balustrade, columns, curtains, &c., are introduced, are decidedly in bad taste. A very light background is also in general an offence against good taste, particularly when the figure is very dark, and the outline hard and sharp.

**Barium.** A metal: used only in combination with chlorine, &c.

**Barium, Chloride of, Iodide of** &c. *See* "Chloride," &c.

**Baryta.** The protoxide of barium. This oxide is precipitated from its solutions by many organic matters, forming either neutral or basic organic salts. These exist, in combination with similar salts of silver, in the presence of chloride and nitrate of silver, in many printing formulæ, and modify the action of the actinic ray, and the nature of the reduced substance. Hence the colour of the photograph is different, according as the salt first used was one of barium or some other metal. Barium appears to have considerable colorific power, and therefore chloride of barium is often recommended as superior to chloride of sodium in the salting of paper.

**Baryta, Acetate of, Albuminate of,** &c. *See* "Acetate," &c.

**Barytes.** Synonymous with baryta, but not equally correct.

**Base and Basic.** In chemistry, that element of a compound which most resembles hydrogen, and is most unlike oxygen in its chemical and electro-chemical relations, is called the base, and in substances composed of two simpler compounds, that compound which is like hydrogen is still the base. In electrolysis, the base travels to the cathode or negative metal, and is therefore called electro-positive; while the acid or other body with which the base was combined, goes to the anode or positive pole, and is called electro-negative. The base travels *in the direction of the* electric current, and the acid *against* the current. The same relation appears to exist between these anions and cathions, in actino or photo-chemistry; for bases are eminently favourable to actinic action, while acids are strongly opposed to it. Alkalis are very strongly basic, and exert a remarkable power as accelerators, while acids are strongly retardative. Of compounds in which the acid and base completely neutralize each other, the action upon bodies undergoing actinolysis is neutral also; hence nitrate of potassa may exists in the nitrate of silver solutions in considerable quantity, and yet give no indication of its presence. When a compound not neutral, contains both acid and base, it is said to be acid or basic according as the acid or basic element is in excess, and retards or accelerates as a pure acid or alkali would do. These facts have not been attended to sufficiently, and hence the discordant opinions of different photographers respecting the useful or injurious properties of the same substance. It should be carefully noted that every compound, whose effects are to be tried, is strictly neutral, or allowances made for its want of neutrality.

**BASIC NITRITE OF SILVER.** Nitrite of silver is a neutral compound of nitrous acid and oxide of silver; but when the oxide of silver is in greater quantity than is required to neutralize the acid, the salt becomes basic, is alkaline to test paper, and acts as an alkali in N. S. solutions. Fused nitrate of silver often contains this nitrite. It then is so strongly acted on by developers, as to give a picture quickly with a weaker developer than would otherwise be necessary; for gallic acid will develope collodion with its assistance, and with the ordinary pyrogallic the picture is formed instantly, and with great force. Crystallized nitrite of silver is sometimes acid, and acts in an opposite manner. Basic salts of lead are sometimes added to nitrate of silver solutions, with the view of forming this basic compound of silver. Its effect in giving intensity to the image is not always observed, but is most apparent in those cases where there is a complete absence of those organic or other matters which usually have a like influence.

**BASIC OXIDES.** Some compounds of oxygen with bodies, have acid properties, and others are neutral, but the protoxides of the metals, and some others, are more or less basic. Water is a neutral oxide of hydrogen.

**Basic Persulphate of Iron.** The red powder which is gradually deposited in solutions of the protosulphate used as a developer is a basic persulphate; that is, it contains sulphuric acid and peroxide of iron in neutralizing proportions, together with peroxide in addition. Now, as the solution was originally without excess of sulphuric acid, it follows that as more of the base has precipitated in this red powder than of the acid, the solution after this decomposition must contain too much acid. This is the reason of its being weaker than at first, and if you neutralize the acid its energy will be restored.

**Bath.** This name is given to any photographical solution, in which plates or papers are immersed, or on which they are floated in any process. It is also given to the vessels in which such solutions are contained. The principal baths are nitrate of silver, the fixing, the toning, and the washing baths, and are treated in their order. The vessels have been constructed of various forms, horizontal and vertical, and of various subtances, glass, porcelain, gutta percha, &c. The porcelain baths are not made of material suitable for resisting the action of the chemicals, or they would be the best, because they are opaque, and are easily procured of any size. Gutta percha is most generally in use, but it is apt to communicate and to receive impurities. Glass, if it could be cast of the required forms and sizes, is undoubtedly to be preferred to anything else, notwithstanding its brittleness. The cemented glass vessels come to pieces.

**Bath.** Aceto-nitrate bath, fixing bath, &c. *See* "Aceto-nitrate."

**Beaufoy's Acetic Acid.** Commercial acetic acid, sold by druggists under that name. It should be of the same strength of the strongest acid of the London Pharmacopœia.

**Bellows Camera.** *See* "Cameras."

**Benzine.** Another name of "benzole," *q. v.*

**Benzoate of Silver.** $Ag\ O\ C_{14}\ H\ O_3$. When formed by double decomposition, this is a white curdy precipitate. It dissolves in boiling water, and falls in crystalline scales as the solution cools. Like other organic salts of silver, it becomes brown under the action of light, and may be used as the basis of a printing-process.

**Benzoic Acid.** Obtained from benzoin by sublimation or by neutralizing the acid which exists ready formed in the benzoin with alkalis; it occurs as acicular crystals, or a white crystalline mass. Liebig found bitter-almond oil having the composition $C_{14}\ H_6\ O_2$ to be converted by oxidizement in the air into benzoic acid and water, which was combined with the acid. He therefore assumed the oil to be a hydruret of a compound radical, which he termed Benzoyle or Benzule $C_{14}\ H_6\ O_2$. This, taking another atom of oxygen, became benzoic acid, while the hydrogen, taking another atom, became water. This acid is decomposed by chlorine in the sun's rays. Of the 5 atoms of hydrogen which the acid contains, three can be successively replaced by chlorine, giving rise to three new acids, which so closely resemble each other that they can only be distinguished by destructive analysis.

**Benzole.** This must not be confounded with benzoyle or benzule. It is a limpid, colourless liquid, S. G. 86, and is obtained by decomposing benzoic acid by slaked lime. Its composition is $C_{12}\ H_6$, and when acted on by the sun's rays in the presence of chlorine, it takes 6 atoms of chlorine, becoming a crystalline solid with the formula $C_{12}$ H Cl. Its use in photography is as a solvent of bitumen in Niepce's processes, and as a solvent of certain gums for making a clear varnish. *See* "Varnish."

**Berlin Ware.** This is a kind of pottery marked with a blue stamp, and of such a quality as to resist the action of nitrate of silver, even when fused in it. Ordinary ware will not do for this purpose, and the porcelain dishes used in photography are altogether very inferior.

**Bi**, prefix. *See* "Nomenclature."

**Bicarbonate of Soda.** $Na\ O,\ 2\ C\ O_2,\ HO$. The salt called by this name in commerce is often a sequicarbonate. Both are used to form with citric acid, citrate of soda; and this, to produce citrate of silver in printing, *q. v.* The bicarbonate is so called, because it contains 2 atoms of carbonic acid to one of soda.

**Bichloride of Mercury.** $Hg\ Cl_2$. Commonly called "corrosive sublimate," and formed thus:—2lbs. of mercury are boiled with 30 oz. of sulphuric acid to dryness; it is then rubbed to powder with 4lbs. of chloride of sodium, and the mixture exposed in a proper vessel to a red heat. Corrosive sublimate rises and sulphate of soda remains. A solution of this in water or ether is decomposed by light; one atom of the chlorine becomes hydrochloric acid, and chloride of mercury or calomel is deposited, being insoluble. The solution itself is also of use in photography. A process for whitening collodion positives (which see) has been contrived with its assistance; and either alone or with other salts it will deepen the tone of a positive to a degree sufficient to allow of its use as a negative. Similar reactions accompany its employment on paper positives; for the picture is first whitened, and then either reappears of itself, or is reproduced by ammonia or other solvents of chloride of silver. By this process collodion pictures are deepened but paper ones are weakened, and both these effects have been taken advantage of. In the processes for photographing the solar spectrum, a subchloride of silver is always had recourse to; one means of producing which is the immersion of a silver plate in the aqueous solution of this salt. Its whitening power on reduced silver may be usefully applied to decolorizing stains on the hands or linen and to removing the yellow colour of the whites in over-toned positive prints.

Bichloride of Platinum. $Pt.\ Cl_2$. This perchloride of platinum is formed by dissolving the metal in nitro-hydrochloric acid, and evaporating to dryness. The dark brown residue forms a deep yellow solution in water, which, when quite neutral, and added to lime water, gives a copious white precipitate in the sun's rays. It has been proposed to determine by the weight of this the actinic power of the light at the time. The aqueous solution has been tried as an etching liquid in engraving photographs on steel plates; and as a toning agent for paper positives instead of chloride of gold.

Bichromate of Potassa. $KO, 2\ Cr\ O_3$. This salt is largely manufactured for calico-printers. Its solution should not be brought into contact with the skin, as it sometimes causes sores difficult to heal. One ounce in ten of cold water forms a saturated solution; it is much more soluble in hot water. It easily gives up one atom of oxygen to deoxidizing bodies, becoming neutral chromate and binoxide of chromium. The binoxide has a tendency to be reduced still further to sesquioxide. When the chromic acid is set free from the potassa by sulphuric acid, it becomes a strong oxidizer, by the facility with which it parts with oxygen; and such a mixture of bichromate and sulphuric acid will determine whether a print has been toned with gold or sulphur, by the greater resistance which gold offers to its oxidizing influence. Light will also act upon the bichromate in the presence of organic matter, and precipitate insoluble oxide of chromium in combination with that matter. This property has been taken advantage of as the basis of several photographic processes, and the chemical action is strictly analogous to that of the use of nitrate of silver alone on paper. A visible image is impressed on the paper, on which reduced silver and other metals (iron, &c.) may be afterwards precipitated by suitable developing solutions. When protosulphate of iron and gallic acid are employed, the picture, or its chemical composition, resembles writing ink. The iron and other metallic solutions are sometimes presented, with the bichromate in the paper, to the action of light, and the variety of modifications appears to be infinite. The insoluble compounds of chromium, formed by light, and the action of the light itself, have both been used in the art of dyeing, the chromium forming a mordant on the textile fabric, in parts exposed to light through a perforated pattern, on which mordant the colours are subsequently applied; or the colours may be put on with the bichromate, and subsequently washed out from the parts not acted on by the light, just as in a similar photographic process on paper. Papers prepared with bichromate of potassa and nitrate of silver have also been found to give images varying in colour from red to green, and blue. We believe, before the publication of the talbotype and daguerreotype processes, if not before that of Niepce's, fixed pictures were taken by Mr. Mongo Ponton, by means of this salt, and the process published. *See* "Printing,"

BICONCAVE. *See* "Lens."

BICONVEX. *See* "Lens."

BIN, prefix. *See* "Nomenclature."

BINOCULAR VISION. Vision, when both eyes are employed. The term is used in contradistinction to monocular vision, in which only one eye is employed.

The effects produced by binocular vision are very remarkable. The subject will be found discussed at some length in the article "Vision," *q. v.*

**Binocular Perspective Portraits.** This term has been applied to photographic portraits produced in a camera which is made to revolve in a horizontal plane through an angle, its axis being always directed to the same part of the sitter. It was supposed that in this way a single portrait could be obtained, which would exhibit the same effects of solidity as duplicate pictures viewed in the stereoscope. This notion is, however, erroneous, as will be found explained in the article on the "Theory of the Stereoscope."

**Binoxide of Nitrogen.** $N O_2$. This gaseous compound has been recommended on account of its reducing properties, as a useful addition to the ordinary developers, with a view to increase their energy. This is a mistake; when passed into gallic or pyrogallic acid it is decomposed, and when it is absorbed by sulphate of iron, it acts more as an acid in moderating its energy and whitening the deposit, than as an accelerator. Old solutions of sulphate of iron which contain it, or are said to contain it, are not so energetic as freshly made ones. Though they give better colour and middle tints, they require longer exposure, and nitric acid is more convenient than the binoxide, and will produce similar effect.

**Bistre Tints.** *See* "Toning."

**Bisulphate of Potass.** $K O, 2 S O_3$. This salt is formed in the process for making pyroxyline with sulphuric acid and nitre, and adheres with such force to the fibres as to require extra good washing. As it has an acid reaction, its presence in collodion would be injurious. One part of it mixed with 4 parts of sulphate of iron has been used as a developer. Its acidity is here the useful quality, and citric acid would be still more useful and convenient.

**Bitumen.** Mineral pitch or tar, supposed to be formed in the earth from the decomposition of vegetable substances. The semi-fluid sorts are distinguished as naphtha, rock-oil, petroleum, or Barbadoes tar; the solid bitumen is distinguished as asphaltum, Jews' pitch, &c. *See* "Asphalt, Photo-engraving, Photo-lithography."

**Black Glass.** *See* "Glass."

**Black Japan.** *See* "Japan."

**Black Sensitive Paper.** Papers have been prepared with certain black chemical compounds, and also with mere mixtures of a black or very dark colour, and sensitive to actinic impressions. In some the lights are bleached into existence by the light itself; in others they are developed by some solvent or chemical process afterwards. They may be used for the production of either positives or negatives.

Black Tone of Prints. *See* "Toning."

Black Varnish. *See* "Varnish."

Blacking for the Inside of Cameras, &c. Of all things which have been tried for covering the inside of lens tubes, cameras, and other pieces of apparatus, nothing has been found so suitable as black cotton velvet. Tubes are sometimes blackened by a solution of bichloride of platinum in water, which precipitates platinum as a smooth black layer over the metal on which it is brushed. Sometimes bone black or ivory black is ground up with water, and a little glue to a proper consistence, and applied as water colour to the surface. But both the colour and texture of black velvet are infinitely superior for this purpose to either platinum or charcoal; the pile of the velvet acting as so many little wells, into which the light enters and is lost. Nothing takes a longer exposure than this, if it be desired to photograph it.

Bleaching. Light has a very powerful effect in bleaching linens, woollen, and other fabrics from which the colour is capable of being discharged, though its effects in this way have not received the attention which they demand. The action of light has often been described as a deoxidizing action, but this is a very loose and incorrect statement of facts. There is no doubt that its effects on some bodies are thus correctly described, but it is equally certain that it exerts on other bodies the powers of an oxidizer; the oxygen which it removes from one class of substances it causes to combine with another class. Its effects, for instance, on organic compounds, are many of them deoxidizing, but are of an opposite character on most organic matters. Nascent oxygen is found in chemical operations to have a powerful bleaching influence, and it is probable that in those cases where light is applied as a bleaching agent, its specific action is to ozonify the oxygen of the air in contact with the coloured material, and thereby cause it to unite with and destroy the dye. Chlorine and some of its compounds are strong bleachers, but it is found that they are nearly or quite inert if no moisture is present: the chlorine decomposes the water, uniting with its hydrogen to form hydrochloric acid, and liberating oxygen, which is the real bleaching element. Now, the decomposition of water by chlorine in the sun's light lies at the foundation of photography, and hence the superior efficacy of chlorine and light together over chlorine alone. In many cases the chlorine itself is combined with organic matter by the sun's power, just as oxygen is; and it should be remembered that chlorine, bromine, iodine, and oxygen are, as to their electro-chemical and actino-chemical properties, bodies of the same class. If light is a deoxidizer, it is also a deodizer and dechloridizer, and if under certain conditions light becomes an oxidizer, it may also in analogous cases become an iodizer. Thus, in photography we not only reduce iodide of silver, but we also, by changing the conditions, form it. Amongst "Miscellaneous Processes" will be found some where reduced and blackened silver salts are again compounded with chlorine, &c., and bleached. That effect, which has been called the reverse action of light, where the usual positive and negative effects are reversed, is probably an analogous chemical change. The substances used in the arts in bleaching photographic and other papers, and otherwise preparing them for the market, are often injurious; this fact should be attended to, and at the same time photographers will do a kindness to bleachers, dyers, and others, if they can make their art practically influential in the arts in general.

**Blistering.** Blistering of the film is a defect which sometimes occurs in albumen processes on glass. It happens on spots where the albumen does not adhere tightly to the glass. The albumen film, like every other film which is capable of imbibing moisture, expands on being wetted. Now should any part of the film be non-adherent to the glass while the surrounding part adheres tightly, the non-adhering part will expand on being wetted, and raise itself into a blister. The proper remedy for this defect appears to be, first, to clean the glass with ammonia or soda instead of alcohol or nitric acid; and secondly, to add a little ammonia to the albumen. The reason of this will be evident from the following considerations. Albumen is a sticky substance, and will adhere to glass like any other sticky substance, provided its surface next the glass be not coagulated. Should, therefore, any trace of nitric acid or alcohol remain on the glass, it would be likely to coagulate the albumen, and render the film non-adherent in those parts, while the presence of an alkali, either in the glass or the albumen would tend to prevent coagulation, and the albumen would adhere to the glass when dry, in the same way as any other sticky varnish. In all the albumen processes on glass, the nitrate bath is strongly acid, and therefore an alkali may be added to the albumen with perfect safety.

The cases of blistering which occur in the albumenized collodion process on glass may be traced to the same cause. The film of collodion is not sufficiently adherent to the glass in those parts where blistering occurs, to prevent the swelling of the albumen from forming a blister. In this process the collodion film should be as porous and adhesive as is consistent with the fulfilment of other conditions; the nitrate bath in which the collodion is excited should be either neutral or slightly alkaline, and the excess of nitrate of silver should be thoroughly washed out of the collodion film.

BLOTTING PAPER. *See* "Filtering Paper."

BLUE GLASS. The question whether blue or white glass is the best for the portrait-room, has been frequently discussed. Blue glass increases the time of exposure more or less, according to the depth and shade of colour, but not to such an extent as to constitute a practical objection to its use. On the other hand, it acts beneficially in modifying the glare of light which is sometimes injudiciously admitted into the glass room, and in this way relieves the eye of the sitter from a painful annoyance, which causes an unpleasent expression. Blue glass stained with cobalt is said to be very permanent in colour. White glass containing manganese is acted on by light, and becomes of a reddish tint, which is very objectionable. When the glass room has a good aspect, and collodion positives only are required to be taken in it, glass slightly tinted with blue may be very advantageously employed.

BLUE MENISCUS. It has been proposed to use a blue meniscus instead of an achromatic lens for taking views, partly on the ground of economy, and partly because it was believed that a better picture might be produced. But these supposed advantages of a blue lens have not yet been demonstrated practically; on the contrary, a blue lens appears to have the disadvantage of increasing the time of exposure, and of yielding an inferior picture to that produced by an achromatic lens. This might have been expected; for an achromatic lens not only combines two of the coloured foci, but compresses together, so to speak, all the other coloured foci, some of which are more or less actinic; while a blue lens merely stops certain coloured rays from passing through it, but leaves the foci of those which do pass through very widely separated. It seems impossible to obtain a satisfactory picture with either a colourless or blue meniscus, in consequence of their having no single actinic focus in which the principal actinic rays are collected. Besides this objection, no single lens can have its spherical aberration diminished or corrected when its focal length and the radius of its anterior surface are given quantities; as happens in the case of the landscape lens.

**Blue Rays.** *See* "Spectrum."

**Body.** This term is applied to substances, in allusion to the quantity of stuff or substance which they contain; in meaning it is opposed to thinness, weakness, transparency, and flimsiness. Hence we have papers without *body* and with body; body colour in opposition to transparent colours; and photographs or pictures with no body, in opposition to those which have plenty of reduced material and of vigour. Beside the starch or glue sizing, inorganic substances, as china, clay, &c. are often added to papers to give to them body; for their effects in photography, *see* "Paper." The amount of body in a collodion film is also a matter of importance.

**Boracic Acid.** $B\,O_3$. This acid has been used in the proportion of 10 grains to the ounce of sulphate of iron developer, instead of acetic or nitric, and that to produce negatives on collodion. It has also been employed so to modify the dark subchloride of silver, which is impressible by the solar spectrum in such a way as to give the prismatic colours, that its power of rendering the green rays is much increased. This application was suggested by the quality it has of producing a very peculiar green colour in the flame of alcohol.

**Borate of Lead.** $Pb\,O\,B\,O_3$. Has been tried as a basis in paper on which nitrate of silver was applied, but without apparent effect on the reduction of the nitrate in the light.

**Borate of Silver.** $Ag\,O, B\,O_3$. Formed in paper by applications of borate of soda (borax) and nitrate of silver, and capable of being printed on.

**Breadth.** This term is used by artists to denote the proper balance and relative value that should exist between the lights and shades of a picture. It is used in contradistinction to the term "spottiness" of effect—a fault which may be illustrated by referring to the appearance of the squares of a chess-board.

**Bromate of Potassa.** $K\,O, Br\,O_3$. An impurity occurring in bromide of potassium, probably not injurious, and easily converted into bromide by fusion at a red heat.

**BROMIDE OF ALUMINIUM.** Obtained by dissolving gelatinous alumina in hydrobromic acid, and evaporating to dryness; and when used in collodion resembles the corresponding ammonium compound.

**BROMIDE OF AMMONIUM.** $N H_4 Br$. This has been used in the preparation of bromided collodion, in the proportion of 4 grains to the ounce, and with a 60 grain N. S. bath; and has been said to possess the property of giving an intense image, even in feeble light, and of representing greens and yellows with more correctness than the iodides. These properties will be discussed under "Bromide of Silver," and "Bromides," *q. v.*

**BROMIDE OF ARSENIC.** $As. Br_3$. This is a ter-bromide, and is formed directly by the action of bromine on arsenic. It has been added to collodion as a preserver and as an accelerator, but it is very improbable that it can be both. In the collodion film it will be decomposed with the formation of hydriodic acid and arsenious acid (common arsenic), and the accelerating power, if any, will be due to the arsenious acid, which will favour the development, for it sometimes has even an alkaline reaction.

**BROMIDE OF CADMIUM.** $Cd. Br$. Occurs in acicular crystals or nacreous scales, and is formed by mixing bromine and filings of cadmium in water; the acicular crystals contain water, but when sublimed, it condenses in the anhydrous pearly scales. It is preferred by many to the other bromides, for the same reasons as the corresponding iodides, viz., its stability, solubility, and purity.

**BROMIDE OF CALCIUM.** $Ca. Br$. Obtained by digesting hydrate of lime in a solution of protobromide of iron, by heating lime in bromine vapour (not bromide of lime, *q. v.*), or by dissolving carbonate of lime in hydrobromic acid. It is white and deliquescent, and its aqueous solution yields silky hydrated crystals. Collodion, prepared with this bromide, is said to improve with age. It is not so good as bromide of potassium for preparing sensitive papers for keeping, because the nitrate of lime formed is deliquescent, and keeps the paper moist, and therefore more prone to deterioration.

**BROMIDE OF GOLD.** $Au. Br_3$. Aqueous bromine dissolves gold, and forms a dark grey bromide. This has been added to collodion containing no iodide, and treated in the usual way. The film thus prepared would contain auro-bromide of silver, and was found to be instantaneously impressed, but apt to fog completely over the plate.

**Bromide of Iodine.** Crystals of iodine absorb bromine, and form first a solid compound of one atom of each element, but afterwards become liquid, when the compound contains two atoms of bromine to one of iodine. This compound is soluble in water, and the solution is employed as an accelerator in the daguerréotype process.

**Bromide of Iron.** Fe. Br. Used in collodion, but, to be useful, must be used in its pure state, and soon after mixing, as it rapidly decomposes the collodion. Nor must the sensitive plate be kept long before development, since the nitrate of iron, which it then contains, would produce irregular action. If carefully employed, the bromide of iron assists development sufficiently to make a very sensitive surface.

**Bromide of Lime.** This, in consequence of its solidity and anhydrous condition, is the most convenient accelerator in the daguerréotype process. It neither gives off aqueous vapour to be condensed on the plate, nor is so awkward to manipulate as the liquid accelerators. In forming it, the bromine is placed in a capsule a little above good hydrate of lime in a close flask. It is necessary to keep the whole as cool as possible, or more or less bromide of calcium will be formed, which would be useless. The bromide of lime is of a beautiful scarlet colour, the calcium salt white. If much heat occurs, the whole of the bromine may go to form this white substance. The proper compound is an oxi-bromide, easily giving off the one atom of bromine and becoming oxide; the other gives up no bromine except to strong acids.

**Bromide of Magnesium.** Mg. Br. A salt occurring in sea water, and the source of bromine.

**Bromide of Mercury.** Has been recommended for collodion, but the protobromide is insoluble. And the perbromide, containing two atoms of bromine, would liberate nitric acid in the N. S. bath and film, and therefore produce a very insensitive and feeble film.

**Bromide of Nickel.** Ni. Br. A deliquescent salt of a whitish colour. It becomes oxidized by the air when in solution, and turns red. It is not so good as the pure alkaline bromide for photographic purposes.

Bromide of Potassium. K. Br. When pure, this is the most convenient bromide to select, when a sensitive surface containing bromide of silver is to be formed by double decomposition. Its usual impurities are carbonate of potassa and chloride of potassium, derived from the carbonate used in its manufacture. The first of these, from its alkaline nature, will be injurious if in great excess; but it is easy to get rid of it by adding bromine to the aqueous solution of the bromide, until a little colour is produced, and afterwards evaporating and fusing. Bromide of potassium has been of service on some occasions, in partially fixing negative and positive proofs, which it does by forming, with the unreduced and insoluble silver salt, a soluble double salt of silver and potassium. Other bromides, and many iodides, chlorides, and cyanides, act in the same way, and even nitrate of silver. These double salts are all partially decomposed by the smallest dilution of their concentrated solutions with reprecipitation of the insoluble silver salt, and their solvent power increases wonderfully with their degree of concentration. They must, consequently, be used in large quantities, when water is to be afterwards freely used in their removal. Hyposulphite of soda comes under the same rule, and cannot be advantageously had recourse to except this law be remembered. The principal use of this and the other bromides (*see* "Bromide"), in photography, has been, in the collodion and paper processes, to form a mixture of bromide of silver with iodide in the sensitive surfaces, and it has been occasionally employed alone, without any iodide. For the advantages sought for in this mixture, *see* "Bromide of Silver," in the next article.

Bromide of Silver. Ag. Br. An insoluble salt of silver, of a yellowish colour, and thrown down whenever bromine in solution, or any soluble bromide, is added to nitrate of silver. It is soluble in concentrated solutions of nitrate of silver, and of various iodides, bromides, and analogous salts, and to a very minute extent in their dilute solutions. Like other insoluble silver salts, it becomes darker in colour in the sun's light, when nitrate of silver, or other soluble salt of that metal, is present; and, like them, it is capable of receiving a latent impression by light, capable of development. When mixed with iodide of silver, it has been supposed by some to give greater sensitiveness, to increase the density of the image, and to produce a better rendering of objects which give off green rays. All these points have been disputed by others, and the opinions as to the accelerating, intensifying, and colour-rendering power of this substance are very discordant. The difference of sentiment in persons who have tried pictures with and without it, arises from want of proper care in the conducting of the experiments, and especially from want of observation as to the purity and neutrality of the solutions employed, and as to the modifying effects of organic matter of different kinds. Nor is any mistake more common than to say one process is more sensitive than another, merely because, with the same exposure to light, that one has given a stronger or blacker colour in the shadows than the other. This difference may exist, and yet the weaker picture may have been more completely impressed by the actinic influence; for the true test of sensitiveness is the complete reproduction of the detail in the darkest shadows, and not the vigour of the blacks themselves. When chloride, bromide, and iodide of silver are precipitated in a pure state from nitrate of silver in excess, and exposed to light, the chloride is the first to *appear* discoloured, next the bromide, and lastly the iodide, and when organic matter is present, the discoloration of all is more decided, and the difference between them is still more marked than before. There is much less difference between the iodide and bromide, than between either and the chloride. When they are acted on by a developer in the presence of organic matter, it is still found that such matter has more effect in the coloration of chloride than of either of the others, and that there is still a difference between the bromide and iodide. But as to their impressibility by light, for the production of a non-apparent image, the order of these three, in similar neutral condition, is reversed, for the iodide is most quickly impressed; though, in the process of development, the organic matter has less power of colouring and giving vigour to the image which it has received, than in the case of the bromide, and *à fortiori* of the chloride. In cases, therefore, where organic matter is present, to affect the result, the addition of bromide, and still more of chloride of silver, in small quantity, will give greater strength to the image; but, at the same time, the sensitiveness is also decreased in a slight degree. But where organic matter does not interfere to a perceptible extent, as in some collodion processes, no improvement will be produced in the sensitiveness of the film, and but little additional intensity given to the picture, by the use of bromides in the preparation.

The greater sensitiveness to green rays which bromide of silver was for a long time thought to enjoy, and for which it was much recommended in the photographing of foliage, is not in ordinary practice found to exist. The coloured rays, to which iodide of silver is not sensitive, but which affect bromide, are a very inconsiderable portion of those which are reflected by green objects in daylight, and scarcely affect the result. But as they exist to a greater proportional degree in artificial light of various kinds, the admixture of bromide of silver will, when they constitute the illuminating medium, be found beneficial.

In thus recommending the use of iodide of silver alone in general operations, we speak only of average cases; for there may occur opportunities where the properties of bromide and chloride of silver may be advantageously had recourse to; and different kinds of organic matter introduced into the formulæ, will no doubt produce corresponding modifications in the results. It is not impossible that bromide of silver may also, by its lengthening the time of exposure, sometimes usefully affect the image imprinted on the iodide with which it is combined.

**Bromide of Sodium.** Na. Br. A salt very closely resembling the bromide of potassium.

**Bromide of Zinc.** Zn. Br. Is formed by passing bromine vapour over heated zinc fused at a red heat, and is very deliquescent. From its slightly acid properties it soon acts upon collodion.

**Bromides.** The most useful salts of this class have been specified above. In the selection of the most suitable for the purpose in hand, attention must be paid especially, 1st, to their freedom from carbonates and oxides; 2nd, to their stability in crystals and in their proper solutions; 3rd, to the nature of the nitrate which they produce in the N. S. bath; 4th, to their degree of solubility in ether and alcohol, when they are employed in collodion. The bromides of the metals cadmium, zinc, &c., are generally the purest and most stable salts; those of the alkaline and earthy bases are more apt to contain alkaline matters. Bromide of potassium is not easily soluble in ether and alcohol, and therefore in collodion is apt to be partially precipitated in fine particles, which produce transparent circular spots in the picture, and to produce, by its little solubility, a film of a misty appearance insensitive to light. The nitrates of the alkalis introduced by their bromides into the exciting bath are perfectly neutral, but those of the metals are slightly acid, though not injuriously. The nitrate of zinc is deliquescent, and helps, when formed in the collodion film, to keep it moist. Nitrate of ammonia is often prejudicial, and therefore, bromide of ammonium, a very unstable compound in collodion, is generally to be avoided. Bromide of iron is also prejudicial, from the decomposition which the nitrate of iron sets up in the nitrate of silver, on the film and in the bath. The choice lies, for most purposes, between the salts of potassium and cadmium.

**BROMINE.** (Βρωμος a stench). A deep reddish brown liquid of a disagreeable odour. In its chemical relations it resembles oxygen, but is a less powerful body, and therefore many bromides will at common, and still more so at high temperatures, absorb oxygen. The displaced bromine then partly unites with the salt, to form bibromide and oxibromide of a red colour, and partly escapes. Its vapour is extremely poisonous; a single drop of the liquid on the beak of a bird, instantly kills it. Its aqueous solution is used to give off bromine vapour in the daguerréotype process, but is not so good for this purpose as the bromide of lime. Bromine has been added to collodion, but it has no advantage over iodine, since the effect of both is the same, viz., to liberate nitric acid in the bath and film.

**BROMO-IODIDE OF LIME.** A mixture of bromide and iodide of lime.

**BRONZE IN PHOTOGRAPHIC PRINTING.** In many processes, both of sun-printing and development, the darkest parts of the impression assume after a time an olive green colour, lighter than the dark brown which immediately preceded it. This has been called bronze, and its production bronzing. It occurs when the paper is rich in silver salts and organic matter, and especially when there is abundance of free nitrate and the exposure is prolonged. With very vigorous negatives to print from, this may be excessive, but there are means of preventing and also of remedying the extreme action. The paper must be rendered less sensitive, or the bronzing can be removed by chloride of gold and other means. *See* "Printing."

**BROWN COLLODION, GALLIC ACID, HYPOSULPHITE OF SODA, NITRATE OF SILVER, &c.** *See* "Collodion," &c.

**BRUNSWICK BLACK.** For the composition of this black varnish, *see* "Varnish."

**BUCKLE'S BRUSH.** The little article which passes by this name is made by pulling out some fine cotton wool by the fingers, which is then placed in a hook formed at the end of an annealed copper or silver wire, and drawn tightly into a suitable glass tube to serve as a handle. It may be used on albumen or paper surfaces, and is, in many respects, the most convenient method of applying chemical solutions. The solutions, when it is used, remain constant in their action, and the papers are more uniformly of the same strength; camel-hair and other brushes are immediately destroyed by nitrate of silver; this brush may be hourly renewed.

**Buff, and Buffing.** A buff is used in the daguerréotype process, for polishing the silver plate, and in the glass processes, for polishing the glass plate. In the former process, it may be either a hand-buff or a buffing-lathe. The hand-buff is made of a piece of deal about sixteen inches long and five inches wide, having a handle at one end, and covered with velveteen, the fine ribs of which are laid *across* the buff. The buffing-lathe is a wheel in the shape of the frustrum of a cone, the axis of which is the axis of rotation, covered with wash-leather or doe-skin, and turned by the foot. Hand-buffs are generally kept in pairs, face to face, to prevent particles of dust from settling on the velveteen. The hand-buff used for polishing glass plates, has a handle on the back, like a blacking brush, the front being padded, and covered with wash-leather.

To use the buffing-lathe, the wheel is put into rapid motion by means of the treadle worked by the foot, and the plate held against the leather. In using the hand-buff, the operator puts an old kid glove on the right hand, takes the handle of the buff in the left, rests the end of it on the edge of a table, and lays the face of the plate on the velveteen; then, putting the fingers of the right hand on the back of the plate, he rubs it briskly backwards and forwards until it has received a sufficient polish; the plate being turned occasionally diagonally, and cross ways, on the buff, and considerable pressure being employed.

A glass plate should first be rubbed dry with a cambric handkerchief, then laid on a pad of paper, and rubbed in every direction with the buff, until the dew from the breath condenses on it in an even sheet, without exhibiting marks or patches.

The plate, whether metal or glass, should be polished immediately before use, and the clean surface should on no account be touched with the fingers.

**Burning-in.** It has been attempted to use photography for ornamental purposes, and also to give increased permanence to photographs, by burning them into glass and ceramic ware. Very little has yet been done in this direction, as the silver which forms the images of an ordinary photograph turns yellow in the furnace, and photographic processes with other metals which yield good colours after toning are at present in an imperfect state. It is possible, however, to apply the arts of photo-lithography, and photo-galvanography, to the purpose of ornamenting ceramic ware, as these processes yield prints in common inks of various colours, which may be treated at the potteries in the ordinary way in which ink patterns are burnt in.

It is impossible to attach too much importance to the burning-in processes of photography, since the permanence of a pure photograph is more likely to be secured in this than in any other way.

Burnishing Photographs. *See* "Agate" and "Mounting."

Burnt-up. A familiar phrase applied to photographs, when, having been very much over-exposed to light, they have a weak misty appearance, and a faint reddish colour. This effect is also sometimes improperly called solarization.

Cadmium. This metal in appearance much resembles tin, but in its chemical qualities it still more nearly resembles zinc, in the ores of which it is found. Zinc is the only metal more electro-positive than cadmium, and therefore the only one which will precipitate it from its solution in the metallic state. It is a scarce metal. Air and moisture scarcely act upon it except it is heated, and this quality makes it valuable in photography, because its salts in collodion are extremely stable, and in the crystalline state they have little tendency to deliquescence and oxidizement.

Cadmium, Bromide of, Iodide of, &c. *See* "Bromide of Cadmium," &c.

Calcium. The metal of which lime is the oxide; but little has been ascertained of its properties by actual experiment. Its compounds with the halogens are generally deliquescent, and prone to oxidizement.

Calcium, Bromide of. *See* "Bromides."

Calomel. Hg. Cl. Protochloride of mercury. This salt is formed in the collodion positive process, when bichloride of mercury in solution is poured over the picture. Ammoniacal gas blackens it, but heat restores the colour, and calomel remains unchanged; liquid ammonia decomposes it, and black suboxide of mercury is one of the results. Some chemists, who take 100 instead of 200 as the chemical equivalent of mercury, call this *di*-chloride of mercury or $Hg_2$ Cl.

CALORIFIC RAYS. The heat rays of the spectrum. *See* "Spectrum." These rays, which reside principally at and beyond the red end of the spectrum, bear a strong analogy in some of their properties to the luminous and actinic rays. They proceed in straight lines, can be reflected from mirrors, refracted through lenses of rock salt, collected into foci, and polarized by various substances.

Heat is an important agent in photography, in assisting many of the chemical reactions which take place; but the peculiar action of the calorific rays, when combined with the actinic in the focus of a lens, appears to be too feeble to affect the result. It has been proposed to separate as much as possible the calorific from the actinic focus of a photographic lens, in order to reduce or prevent any injurious action which might be due to the concentration of the calorific rays emitted by bodies; but as glass has the property of stopping, to a great extent, the heat rays emitted by terrestrial bodies (though not from the sun direct), this precaution would scarcely have any practical advantage. The effects of heat on the various sensitive chemicals used in photography have not yet been correctly ascertained by experiment. As a general rule, photographic operations are conducted with the greatest certainty and uniformity at a temperature of about 60° Fahrenheit.

CALOTYPE PROCESS. (Gr. καλος, beautiful, τυπος, an impression.) Under this head are included certain processes for producing negatives on paper, which are identical in principle, and differ only in the manipulation.

The principle of the calotype process is as follows:—1st. To prepare and expose in the camera a sheet of PAPER rendered sensitive by being impregnated with a mixture of iodide of silver, nitrate of silver, and organic matter. 2nd. To develop the picture by means of gallo-nitrate of silver or some other similar developer.

The chief difference between the various processes which are classed under the term calotype, consists in the mode of rendering the paper sensitive, that is in the order in which the ingredients are introduced, the mode of development being nearly the same in all, and merely involving a difference in the strength of the developer and the mode of applying it.

A sheet of sensitive calotype paper contains a *large* quantity (comparatively speaking) of iodide of silver, a *small* quantity of free nitrate of silver, a *small* quantity of organic matter, and a sufficient quantity of an organic acid to keep the lights of the picture clean during the development.

It will be seen that in one of the methods about to be described the paper itself contains sufficient organic matter; but it will be observed that in this process the paper undergoes complete immersion in a *strong* bath of nitrate of silver. On the other hand, in one of the other methods it will be shown that when the organic matter in the paper has no opportunity of coming into contact with a *strong* bath of nitrate of silver, it becomes necessary to add organic matter of an energetic kind to the exciting solution. Bearing these facts in mind, the principle of the various calotype processes will be clearly understood.

The calotype processes may be classed under two heads. The first class comprises two processes in which the paper is first coated with insensitive iodide of silver, and then excited by a weak solution of acidified gallo-nitrate of silver; the second class, those processes in which the paper is first coated with an alkaline iodide, and then excited by immersion in a *strong* bath of nitrate of silver, the excess of free nitrate being subsequently removed by washing. Among the latter processes, one will be selected for minute description, which appears to be, of all the calotype processes, the simplest in manipulation and most scientific in principle. In the processes of Class I., the paper is iodized with iodide of silver; in those of Class II., with a soluble alkaline iodide. The first kind of iodized paper may, for convenience, be called "argento-iodized" paper, the second kind simply "iodized" paper.

## CALOTYPE PROCESSES. CLASS I.

There are TWO methods which come under this head. In the first, argento-iodized paper is prepared by what is called the "double wash;" in the second, by the "single wash." In all other respects the two methods are identical.

*To argento-iodize the Paper by the Double Wash.*—Float the face of the paper on a bath containing 20 grains of nitrate of silver to the ounce of distilled water. Let it remain a minute or two on the bath, then hang it up to dry. Next immerse it in a solution containing 25 grains of iodide of potassium to the ounce of distilled water. Let it remain a minute or two in this solution, the exact time depending on the kind of paper employed, and requiring to be ascertained by experiment. If too short a time is allowed, the whole of the nitrate of silver is not decomposed, and the paper darkens in the light; if, on the contrary, too long a time is allowed, the iodide of potassium in the bath dissolves the iodide of silver in the paper. The time of sojourn in the iodide bath is therefore rather critical. On removing the paper from the bath, let it drain, and then immerse it in a pan of water, in which it must be allowed to soak, the water being changed several times, until the *whole* of the free iodide of potassium is removed. This soaking operation is rather troublesome, and the texture of the paper is decidedly injured by it. Should any excess of iodide of potassium remain in any part of the paper, it would decompose the weak exciting solution and produce insensitive iodide of silver, and consequently a white patch in the negative. When the paper has been sufficiently washed, hang it up to dry. It is of a yellow primrose colour. When dry, it may be kept for use in a portfolio. It is not sensitive to light.

*To argento-iodize the Paper by the Single Wash.*—Lay the paper on a board with a piece of blotting paper under it, and brush over it a solution called "double-iodide" *i.e.*, a solution of iodide of silver in iodide of potassium; (*see* "Double-Iodide.") The best kind of brush is a large round one of camel's hair, bound with string or silver wire. Apply the solution copiously both longitudinally and transversely, inclining the board, and keeping a flowing edge. Hang up the paper to dry in a room having a pure atmosphere, free from sulphurous and acid vapours, which bleach the reddish tint that the paper ought to assume. When very nearly or even quite dry, immerse the paper in a pan of water as before, in order to remove completely the excess of iodide of potassium which it contains. Two or more papers should not be soaked in the same pan, but each paper should have a separate pan. When sufficiently washed—an operation which requires several hours—dry the paper and put it away for use.

Argento-iodized paper may be kept for some weeks without losing its good qualities. Some persons even affirm that it may be kept indefinitely in a dry place. It is said, on good authority, to be much improved by exposing it for an hour or two to strong sunshine. When this is done, it should not be excited immediately after insolation, but kept for some days previously in the dark, since it has been found that paper absorbs light in sufficient quantity to react on a sensitive surface placed in contact with it in the dark.

In comparing the two methods of iodizing the paper which have been described, it will be seen that the first is the most economical, but at the same time the least certain. A considerable quantity of iodide of potassium is wasted in the second mode of iodizing, and the washing operation is rather more tedious.

The paper having been iodized by either of these methods, the remaining operations are the same, and are as follow:—

*To excite the Paper.*—Make two solutions, one a saturated solution of gallic acid in cold distilled water, which call solution A; the other, by dissolving 50 grains of nitrate of silver in 1 ounce of distilled water, and adding 1 dram of glacial acetic acid, which call solution B. Immediately before use, mix, in a chemically clean measure, 1 ounce of distilled water, 15 drops of solution B, and about as many drops of solution A, the number of the latter depending on the temperature and kind of paper employed.

Lay the paper on a board with a piece of blotting-paper beneath, and apply this mixture copiously to it with a clean Buckle's brush. Hold up the paper to drain for a minute, then blot off the surface moisture with clean blotting paper, and put the sensitive paper into the dark slide.

*The Exposure.*—The average time of exposure, with a good light, a lens of fifteen inches focus, and a half-inch stop, is seven minutes.

*To develop the Picture.*—Lay it on a board, and brush over it, with a clean Buckle's brush, a mixture composed of 3 parts of solution A, and 2 parts of solution B. The picture, the darker parts of which are at first faintly visible, soon comes out of a fiery red tint. At this stage of the development it is necessary to check it, in order to obtain dense blacks instead of feeble reds in the darker parts of the negative. To accomplish this, brush over the picture, and complete the development with a solution of gallic acid alone.

Under this treatment the reds soon darken and intensify, and become eventually opaque blacks. The entire development should occupy about twenty minutes. It is an excellent plan, after having brushed on the gallic acid, to lay the paper face downwards on a horizontal glass slab, on which a quantity of gallic acid solution has been previously spread.

*To fix the Picture.*—When the details are fully out, and the blacks of the proper intensity, wash the negative with water, and then immerse it in a solution containing 1 part of hypo-sulphite of soda to 4 parts of water. Let it remain until the whole of the yellow iodide of silver is removed from the paper. Then wash and soak in water for several hours, changing the water several times, in order to remove the whole of the hypo from the paper. Lastly, hang it up to dry.

The negative is now finished, and may be waxed at any convenient time. *See* "Waxing."

There are one or two important points to be observed in this process:—

If the iodized paper is excited with a weak solution of aceto-nitrate of silver containing no admixture of gallic acid, it is quite as sensitive, or even *more* sensitive than before, but the negative is devoid of density, and the dark portions are grey, feeble, and metallic, like the dark parts of a collodion positive on glass when viewed by transmitted light. This sufficiently shows the importance of introducing organic matter with the exciting solution. But the above effect does not take place equally with all kinds of paper. There is a coarse spongy kind of Whatman's paper, sized perhaps in a peculiar way, in which the gallic acid may be *advantageously* omitted in the exciting solution. If, on the other hand, too much gallic acid is added to this solution, the paper is liable to become brown all over, particularly in hot weather. The process has therefore its drawbacks and uncertainties, particularly at that season of the year when photographic tourists are most in want of a good process. A good test of the proper state of the sensitive paper, is to take a strip into the light. If it darkens instantly to a cold grey tint, incapable of being intensified by the further action of light, the negatives will probably be grey and feeble; but if it darkens to a redder tint, which gets still darker by continuing the exposure, there is sufficient organic matter present to give a good intense picture.

## CALOTYPE PROCESSES. CLASS II.

In these processes, the operations consist in first impregnating the paper with an alkaline iodide; next, rendering it sensitive by immersion in a strong bath of aceto-nitrate of silver, and developing with gallo-nitrate of silver rather weaker in silver than in the foregoing process. It is not found necessary in this process to introduce organic matter into the paper, as that which the paper itself contains, in the form of size, is in general sufficient; but should that not be the case, the effects and their remedy are obvious enough. With respect to the introduction of organic matter, it appears that an extremely minute quantity, in combination with sensitive iodide of silver, is capable of producing a very marked effect, and that the effect of organic matter is not increased by overloading the paper with it. This remark is very important, as it shows how wrong in principle are those processes in which a large quantity of organic matter is introduced.

*To iodize the Paper.*—Immerse a number of sheets, one at a time, in a solution of iodide of potassium containing 20 grains of the salt to the ounce of distilled water. Let them remain together in the bath for at least a couple of hours, then hang up to dry. When dry, the papers assume a reddish or even deep purple tint, according to the quantity of starch which they contain. When dry, put them away in a portfolio until wanted. They may be kept for a few weeks in a dry place without deterioration.

*To excite the Paper.*—Immerse it in a bath of acceto-nitrate of silver, containing 35 grains of nitrate of silver, and two scruples of glacial acetic acid to the ounce of water. First, float the face of the paper for a few seconds on the bath, then immerse it entirely. Leave it about three minutes, and then remove it into a dish of distilled water. Rinse it well in this, then press it between blotting-paper and put it into the slide, with its face to the front shutter.

It may be well, when the nitrate bath is first made, to saturate it with iodide of silver, and filter.

*The Exposure.*—This is about the same as in the former process.

*To develop the Picture.*—The paper will scarcely exhibit any trace of an image. Immerse it in a solution of gallic acid, to which a few drops of aceto-nitrate have been added. The picture should begin to appear of a red and not a gray tint, which should darken in the course of the development to an intense black in the darkest parts. The dish should be chemically clean, and the developer should remain colourless throughout; the whites of the picture will not then be discoloured, and the development will proceed much more quickly.

If the picture comes out grey and metallic, exhibiting all the detail, and having but little intensity, it indicates a want of organic matter in the sensitive film. To remedy this, add a little citrate of soda to the iodizing solution, and substitute a little chloride of sodium for the iodide of potassium. This will entirely alter the character of the picture, increasing the density of the blacks, and also the necessary time of exposure. Sugar, honey, gelatine, and substances of this kind added in large quantity to the iodizing solution produce but little effect. Serum of milk contains some organic salts, which are decomposed and form organic salts of silver, and this substance acts much more powerfully than those before mentioned, which require to undergo decomposition before they act with effect.

As a rule, it may be considered that organic *salts* which at once decompose nitrate of silver and form an *insoluble* organic compound with oxide of silver, act most powerfully in producing the effects due to organic matter; and that, next to these come such organic substances, (gallic acid, for instance,) as, when added to nitrate of silver, form a mixture which is *immediately* decomposed by light, and an insoluble organic compound of silver produced.

*To fix the Picture.*—Proceed as described in the former process.

Having now described the simplest form of the second class of processes, it remains to indicate the various modifications which it has assumed.

The first and most important of these consists in waxing the paper *before* iodizing it. This modification has received the name of the

### WAXED-PAPER PROCESS.

Wax being nearly inert as regards its power of combining with silver and forming an organic compound of that metal, its presence does not modify the character of the negative in any appreciable way as regards density; nor does it appear that any other good is derived from the introduction of wax in the first stage of the process, than stiffening the paper, and rendering it less liable to be torn in the various operations.

The greasy impurities contained in all commercial samples of wax cause it to repel water, so that there is some difficulty in getting a sheet of waxed paper to imbibe the solutions. This may be overcome by dissolving a few shreds of gelatine in the iodizing solution, and by adding a little alcohol to the gallic acid. In all other respects the waxed-paper process is the same as that previously described.

The other processes of Class II. are merely modifications of the waxed-paper process in its simplest and best form, as described above. They consist in adding various organic substances, such as rice-water, gelatine, honey, &c., and also bromides, cyanides, fluorides, &c., to the iodizing solution. Most of these organic substances are nearly, if not absolutely inert, and the salts added are of very questionable utility. Under these circumstances, and as the above modifications are quite empirical, if not demonstrably injudicious, it would not only be useless, but even mischievous, to describe them at length. A word or two, however, may be said on the subject of substituting iodide of cadmium for iodide of potassium in the paper processes. It is a tolerably good salt to employ when pure, and the negative is free from the white spots which sometimes occur when crystals of iodide of potassium remain undecomposed. But the nitrate of cadmium introduced into the nitrate bath has an acid reaction which resembles in a slight degree the reaction of free nitric acid. This renders the paper less sensitive, increases the difficulties of bringing out the details of the shadows, and diminishes the density of the blacks. On the whole, iodide of potassium is decidedly the best salt to employ.

Before concluding an article which embraces a description of the most important modes at present known of obtaining negatives on paper, it may be well to discuss the points in which these processes are inferior to the analogous ones on glass.

The principal fault of a paper negative consists in the fact, that a sheet of paper, waxed in the ordinary way, is not evenly transparent when held against the light, but exhibits a granular appearance, and sometimes the marks of the wire frame used in its manufacture.

Before a paper negative can be expected to rival one on glass, this radical defect must be overcome. Now, it will be found that if a sheet of paper is dipped for a minute or two in linseed oil and dried, it will exhibit precisely the same defects as a sheet of waxed paper; but if left in the oil for a week, so as to imbibe it thoroughly, it will appear as evenly transparent as could possibly be desired. It is obvious, therefore, that the radical fault of a paper negative consists in the paper not thoroughly imbibing the wax, which would evidently be a work, not of minutes but of hours, or even days. Fortunately, however, a sheet of paper may have its power of imbibing wax greatly increased by a very simple process. If one half of a sheet of paper is immersed in a mixture containing equal parts of muriatic acid and water, and then rinsed thoroughly in several changes of water, and dried, it is found, in waxing the whole sheet, that the half which has been treated in the manner described, imbibes the wax much more readily than the other half, and presents a beautifully even appearance. It does not appear that the treatment with acid has any bad effects in the subsequent operations, but the matter has not yet been sufficiently tested.

A finished negative on plain paper may be treated with muriatic acid with perfect safety, since it does not attack the image, unless very strong. In this case, about one part of acid to ten parts of water will be strong enough. This treatment may therefore precede the waxing, and the negative will be improved by it.

Another frequent defect of paper negatives is a want of half tone, too great intensity in the blacks, and too little detail in the shadows. In such cases the fault may generally be corrected by leaving out organic matter, diminishing the acidity of the nitrate bath, and increasing the time of exposure.

Lastly, the paper processes are very insensitive, when compared with wet collodion. This may proceed principally from the great quantity of acid used in the aceto-nitrate bath in paper work, as compared with the neutral-nitrate bath in collodion work. When a collodion plate is excited in a bath of citro-nitrate sufficiently acidified with citric acid for a paper negative, the excess of nitrate of silver washed off, exposed wet, and then developed with gallo-nitrate, it is very little more sensitive than a piece of paper treated in the same way. On the other hand, if a paper negative is excited in a nearly neutral-nitrate bath, exposed wet, and developed with the pyrogallic developer used for collodion, it blackens all over. A paper negative, therefore, requires more acid to keep the lights clean, and will not bear so energetic a developer as a collodion negative. This is the principal reason of the want of sensitiveness of paper as compared with collodion. There are other causes which tend to increase the sensitiveness of the collodion film; but these are secondary.

One more remark:—Acetic acid, although it appears to act exceedingly well in the paper processes, is both costly and inconvenient to the tourist. Citric acid has been proposed as a substitute. It has not yet, however, been thoroughly tested; still, there is great reason to believe that it will answer exceedingly well. Acetic acid has the property of penetrating the paper more readily than citric, and that would perhaps be found an advantage in preventing the formation of a precipitate which sometimes occurs in the interior of the paper, and which may be traced to deficiency of acid. This defect is more liable to occur in foreign paper containing a free alkali in the size, than in English paper sized with alum, and which has consequently an acid reaction.

**Camera Obscura.** (Latin, "Camera," a chamber). A dark box, in which the real image formed by a convex lens is received on a focussing screen. A photographic camera is one in which a sensitive photographic tablet can be inserted to receive the image.

As might have been expected, there are many forms of photographic camera, and most of them fulfil *to a certain extent* the required conditions, but none appear to satisfy completely *all* the conditions of a really good instrument. We shall therefore, in the present article, first describe briefly some of the common forms of the camera, and point out their defects; and then suggest such an improvement upon them as would be free from the same objections.

*The Folding amera.*—The Csimplest form of photographic camera, is that called the "Folding Camera." In this instrument, the sides are made of two longitudinal pieces hinged together, and also to the top and bottom, so as to fold between the top and bottom when the front of the instrument is removed. This is a very convenient arrangement as regards portability. The front of the folding camera has a double slider for carrying the lens, so that the lens can be either raised or lowered when the camera is in its usual position, or on its side for taking upright views. The length of this camera is invariable, and the picture is focussed by means of a sliding adjustment of the brass work which carries the lens, the lens being mounted in a tube which slides in a jacket. This form of camera answers tolerably well for views, when it is not required to work within a few degrees of the sun; but when it is required to take skies, or work in the face of a strong light, the folding camera allows too much diffused light to fall on the picture. This defect cannot be remedied without completely altering its form.

It would be a great improvement to the folding camera, if provision were made for inserting a diaphragm at about one third of the distance between the lens and the picture, for the purpose of cutting off the light which falls on the sides of the camera, and is thence reflected on the picture. The picture formed by the lens is circular and not oblong, so that four segments of what would be an illuminated circular disc, are thrown on the sides of the camera, and a great deal of light is thus reflected on the picture, the whole of which would be intercepted by the proposed diaphragm. These segments of light will be perceived on looking into the camera, with the head and shoulders covered with the focussing cloth. The light reflected in this way has no doubt caused many failures, for which the chemicals have had to bear the blame.

The common folding camera is therefore a useful and portable but not a comprehensive instrument, and it is faulty in a particular which it is very important to remedy.

*The Expanding Camera.*—This camera may be used either for portraits or views. It is composed of two parts; the front part rigid and carrying the lens, the after part sliding in the front part, and carrying the dark slide and focussing screen. This camera may be brought to within a comparatively short distance of the object to be copied, and the focus of the lens proportionally lengthened. It should be made to take square pictures of the largest dimensions which the lens will cover; there will then be no necessity for placing it on its side when it is required to take an upright picture. The same kind of diaphragm should be employed as was recommended in the folding camera.

In every expanding camera, the end which carries the slide should be provided with adjustments for the purpose of placing the plane of the picture at various angles of inclination with respect to the axis of the lens. These adjustments are so extremely useful in enabling the operator to overcome difficulties which are continually occurring in practice, that no camera can be considered perfect without them.

No provision is made in the common expanding camera for intercepting a vast quantity of diffused light, which is likely to enter when a lens of large aperture is used, or when the instrument is brought to face a strong light. An arrangement which will be described presently, will be found to remedy this defect. The expanding camera can be focussed either by means of the sliding body, or the sliding tube which carries the lens.

*The Expanding and Folding Camera.*—This is merely an expanding camera, the front and after bodies of which are made to fold. Its merit is, that it can be packed in a smaller compass than the common expanding camera.

These are the principal forms of camera which are found in the hands of the professional photographer; but a great number of other kinds have been invented by ingenious persons, and are to be found principally among the paraphernalia of eccentric amateurs. Some of these may be briefly mentioned.

*Archer's Camera* is a box provided with arm-holes and india-rubber sleeves in the sides, and a piece of yellow glass on the top. All the manipulation of the collodion process is performed within the camera, and no dark tent is required.

*The Bellows Camera* is an expanding one, in which the front and after bodies are connected by an expanding cover, resembling the bellows of an accordeon.

Some other forms of camera have cloth sides connecting the lens with the frame which carries the dark slide, and which blow about in the wind.

Other kinds have been invented, which are remarkable for their extreme portability, being made of a number of hoops of gutta-percha, which are inflated, and covered with a cloth. One of these bears the name of the Pocket Camera, and, armed with this ingenious apparatus and a walking-stick tripod, the "pestilent fag and toil," as it has been called, of out-of-door photography, may be avoided. But these instruments are generally found to have a screw loose when required for use.

The bare mention of such contrivances as these will suffice, as they possess no real practical merit, and do not remedy any one of the radical faults of the common apparatus. It is not our object in this work to record and perpetuate matters which experience has shown to possess little or no value, but rather to suggest, if possible, improvements on established forms and methods. Enough, then, has been said about the photographic camera *as it is.* We will proceed at once to discuss its weak points, and, if possible, to provide a remedy for them.

The radical fault of all the present forms of camera is, that they allow the image to be diluted with light that is extraneous to it, and which gets in and finds its way to the sensitive surface, thereby producing fog on the shadows and general discoloration, and rendering it next to impossible to obtain a *clean* picture with *sufficient exposure* to bring out all the details. Now, the way in which diffused light enters, and the course it takes from the lens or window in front to its destination on the sensitive tablet may be easily exhibited by the aid of a diagram, and the remedy pointed out.

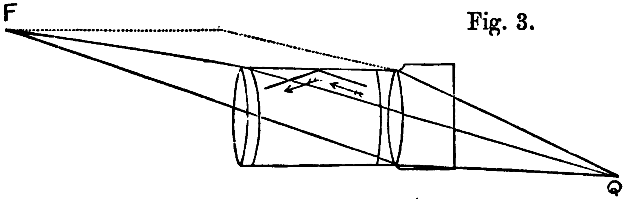


Fig. 3.

If the camera is well made and light-tight, the only way in which diffused light can enter it is by the lens. Let us see, then, in what way the construction of the lens is likely to produce this evil.

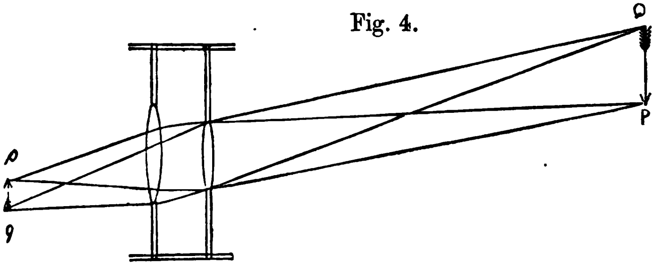
Fig. 3 represents an ordinary portrait lens mounted in a tube: the anterior and posterior lenses being of the same size, and the inside of the tube being blackened with chloride of platinum, which merely changes the colour of the brass without destroying its polish. This is the way in which portrait lenses are generally made and sold.

Now observe what follows:—

Q is the origin of an oblique pencil. Rays from it cover the whole of the anterior surface of the first lens, and the pencil, after refraction, follows the course indicated by the figure. One half of it is incident on the upper part of the posterior lens, and finds its way to the focus F, but the other half falls on the inside of the tube, and is reflected as shown by the arrows. These reflected rays, together with those from *all* the other oblique pencils that are similarly circumstanced, pass through the posterior lens, and produce a large circular disc of light in the centre of the picture. In this arrangement, not only has the central part of the picture more light in consequence of the direct incidence of the central pencils, but one half of the rays of the most oblique pencils is lost, and a portion of those that are reflected from their true course are added to the already too luminous centre of the field.

There are two modes by which this very serious evil may be remedied. One is objectionable, as it involves an error in principle. It consists in placing a stop midway between the lenses, and thus preventing the reflected rays from the inside of the tube from entering the camera. But this plan not only cuts off a part of every oblique pencil, but it compels the part that is available to pass through the *outside* of the front lens, whereas every pencil should pass *centrically* through that lens. The other plan is correct in principle, and will be understood by referring to Fig. 4.

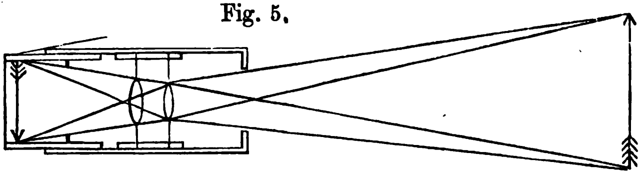
Fig. 4.



In this arrangement of the lenses, the posterior lens is larger than the anterior, and they are not mounted in a tube, but in wooden partitions; no reflected light can, therefore, by any possibility enter, and none of the rays from the oblique pencils are cut off. Every pencil passes *centrically* through the front lens, and *excentrically* through the posterior lens, as it ought in order to get the maximum flatness of field.

But even this arrangement is not sufficient to produce a clear picture when the lenses are exposed to a strong light, the bright part of the sky, for instance. Diffused light exists in the atmosphere, and if we wish to see distant objects clearly, we must look at them through a tube. The stars, for instance, are visible at noon-day from the bottom of a well. Bearing this principle in mind, an important addition should be made to every camera, in the shape of a long darknened tube in front, as shown in Fig. 5, which is a section of a camera, with all the proposed improvements introduced.

Fig. 5.



A camera constructed on this principle would be equally suitable for views or portraits, because its lens would give as flat a field as an ordinary view lens, and splendid definition might be obtained by using a stop immediately in front of the front lens. By removing the stop, and working in a strong light with a full aperture, it would be suitable for taking instantaneous pictures. It was with a lens of this kind that M. Flacheron produced his magnificent views of Rome some years ago, and it is surprising that this form of lens should have gone out of fashion, and been supplanted by one in which everything is sacrificed to the central pencils. The great merit of a photograph is to be equally good in every part, and not to have the edges of the field sacrificed to the centre, a defect which, in views of landscapes or architecture, is perfectly unbearable.

Should it be necessary, when using the above form of camera, to turn its axis upwards, the slide must be always kept strictly vertical by means of the arrangement for that purpose, otherwise, all the vertical lines would appear to have a vanishing point in the zenith. The camera and slide should be square, and the plates large enough to take in the whole of the circular picture that is formed by the lens. Circular views are extremely natural and pleasing, particularly when softened off into darkness at the edges. It is a circular picture which is always formed on the retina, and a view bounded by straight lines at right angles always conveys to the mind the idea of looking at things through a rectangular hole in a box, and interferes with the idea of space and freedom of range. There is certainly something unnatural and disagreeable about it. Large circular pictures are remarkably fine when viewed in the reflecting stereoscope.

*Copying Camera.*—This camera is used for obtaining copies of photographs or prints, either by transmitted or reflected light, of a different size from the original. When the copy is to be less than one half the linear dimensions of the original, the ordinary camera, with a portrait or view lens, may be employed; but when the copy is to be nearly as large, or even larger, than the original, some modifications must be introduced in the form of the ordinary camera, and also in the lens.

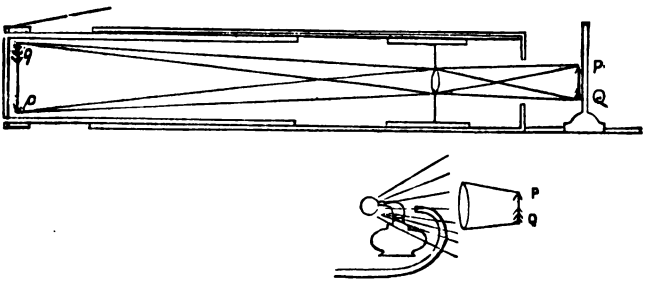
The principle to be borne in mind in copying an object on a different scale is this—that the linear dimension of the copy bears to the corresponding linear dimension of the original the same ratio that the distance of the copy bears to the distance of the original from the lens. For instance, let C be a certain linear dimension of the copy, and O the corresponding linear dimension of the original, and let U be the distance of the original from the lens, and V the equivalent focal length of the lens corresponding to the distance U; then $C : O :: V : U$.

Hence we arrive at the following important conclusion, viz., that so long as the ratio $V : U$ remains constant, U may be increased as much as you please. Now, as the principal defects of photographic lenses proceed from the obliquity of the lateral pencils, and as the obliquity of these pencils is diminished in proportion as U is increased, it is evident that the lens should not be brought so near to the object to be copied as to introduce very oblique pencils, but that it should be placed at a distance from it equal to at least three times the longest dimension of the object to be copied, and be of sufficient length of focus to give an image of the required size.

In ordinary photographic work, pencils having an obliquity of from 17° to 20° are introduced, and the lens has to be so constructed as to meet this difficulty; but the form of lens best calculated for giving a flat field when pencils of great obliquity occur, is not that which at the same time gives the greatest distinctness of focus of the central pencils; that is to say, if the central pencils alone had to be corrected in the best possible way for spherical aberration, the form of lens which this condition would impose would not be such as to satisfy at the same time the conditions necessary for flatness of field when very oblique pencils are introduced. When, therefore, the necessity for obviating the defects due to obliquity is in some measure removed, the form of the lens may be so modified as to remedy more perfectly the defects of central pencils. In the lens of a copying camera, therefore, the posterior lens need not be much larger than the anterior; in fact, a single achromatic lens, like the object-glass of a telescope, may be employed. But this subject has not yet received the attention which its importance deserves, and the best possible form of lens for the copying camera remains yet to be investigated.

In copying a small photograph or print on a larger scale, the projecting front of the camera should be continued until it nearly touches the picture, and this should be illuminated as strongly as possible, either by the sun, or strong diffused daylight. When artificial light is employed (the oxycalcium light, for instance), it may be brought very near to the end of the camera, and its light concentrated on the picture by means of a convex lens, as shown in Fig. 6.

Fig. 6.



Whenever the light is sufficiently intense to allow of a stop being used, it should certainly be introduced as a remedy for the unavoidable defects of the lens. When an achromatic convex lens is used, like that in Fig. 6, the stop should be placed immediately in contact with it, either in front or behind.

Small bas-reliefs may be copied in this way very successfully, by throwing the light obliquely on them, and using a reflector to diminish the intensity of the shadows. It is generally found difficult in practice to place the plane of the sensitive surface accurately parallel to the plane of the picture to be copied, and unless this is done, the lines of the copy are distorted. Where the original is small, it may be placed on a holder connected with the bottom of the camera, as shown in Fig. 6; but, if this is not possible, the end of the sliding part of the camera should be fitted with the arrangement employed in the ordinary camera, for allowing the plane of the picture to be inclined at any small angle to the axis of the lens. By means of these adjustments, any distortion of the image on the ground glass may be easily remedied.

When the picture to be copied is transparent, it should, if possible, be inserted within the camera, the front of which should be sufficiently lengthened to receive it, and the light which is transmitted through it should either proceed from the sky, or a large white illuminated disc, or an artificial light placed behind a condenser. When practicable, the sky should always be used as a luminous background, in preference to any other kind of light. This will be fully explained in the article on "Micro-Photography." When the sky is used as the source of transmitted light, the instrument may be mounted on a stand, in such a way as to turn on an axis, to permit of its being directed to any part of the heavens. When the copying camera is placed with its axis vertical, the free nitrate on a sensitive plate does not drain towards the lower part, and the picture is consequently more uniform in density. Whenever it is practicable, therefore, to point the instrument towards the zenith, this should certainly be done.

Having now explained the *principle* of the construction of a copying camera, it will be unnecessary to enter further into detail, as the operator will find no difficulty in modifying his arrangements to suit any particular case.

*Solar Camera.*—This is a form of copying camera, in which the sun's rays are transmitted through a transparent negative. It only differs from the copying camera in which artificial light is employed, in the form of the condenser necessary for modifying the course of parallel rays, and preventing the formation of an image of the sun between the lens and the sensitive surface. This form of condenser will be described in the article on "Micro-Photography."

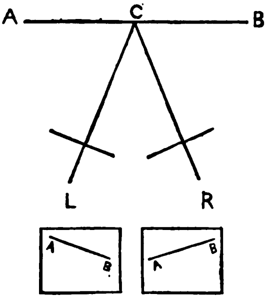
*Stereoscopic Camera.*—The stereoscopic camera is employed for taking duplicate pictures of objects, from different stations, to be viewed in the stereoscope.

There are two forms of stereoscopic camera. The first arrangement merely relates to the camera stand, which is so contrived as to allow the camera to be shifted from one end of it to the other, and at the same time have its axis always directed towards the same point. In this way the two pictures are taken separately, in an ordinary single camera, and the contrivance, which merely affects the stand, should be called by some appropriate name.

Since the above mode of taking stereoscopic pictures involves an error of principle, which will be pointed out, it becomes unnecessary to describe the various modes by which an operation that is erroneous in principle is rendered more or less convenient in practice. It will be sufficient to point out clearly in what this error consists, and then to pass on to the description of the other form of stereoscopic camera which is scientifically correct.

In taking stereoscopic pictures, the axis of the camera in its different positions should strictly preserve its parallelism, however wide apart the stations may be; otherwise, there will be more or less difficulty in properly combining the images seen in the stereoscope. This will be evident from the following considerations :—

Fig. 7.



In Fig. 7, let A B be a horizontal line above the level of the eye, (the parapet of a high building, for instance,) and let L R be stations from which stereoscopic views are taken. Let the axis of the camera be directed, in both cases, towards the same point C. Then, the line A B in the pictures will not be horizontal, but will tend to a vanishing point. In the picture taken from L, (the left station,) the vanishing point will be on the right-hand side beyond B, and the line A B will be inclined, as shown in the figure beneath L. In the picture taken from R, (the right station,) the line A B will incline towards the left side, and tend to a vanishing point beyond A, as shown in the figure beneath R. When, therefore, the two pictures are mounted and placed in the stereoscope, the points A, A, will not be on the same horizontal line, and it will be found impossible to combine either the two A's or the two B's, so as to produce stereoscopic effect, without turning the head, so as to bring, from the points A, A, the right eye downwards and the left eye up, and *vice versâ*, for the points B, B. In other words, it will be impossible to combine either the two A's or the two B's, with the eyes on their normal horizontal line.

For, suppose we call R the right eye and L the left, and consider the line L R which joins the eyes to be horizontal; then, if we join the optic axes L A, R A, and produce them, it is evident that they cannot possibly intersect in a common point, unless the two points A A are in the same horizontal line; for, otherwise, the lines R A, L A, will not *lie in a plane*, and straight lines which do not lie in the same plane, cannot possibly meet in a point.

The convergency of the two directions of the axis of a camera, when taking duplicate views for the stereoscope, is therefore shown to be wrong in principle; and if the difficulty in uniting the images is not perceived in practice, it may perhaps be that the error is in most cases trifling in amount, and the head, by a series of small motions, brings the eyes into a succession of proper positions for uniting the several points of the images.

The scientifically correct form of stereoscopic camera is that in which the axis of the instrument always preserves its parallelism, so that the two pictures are taken *on the same plane*. When the pictures are small, and the stations near together, this may be very conveniently effected by combining two cameras in one, and taking both pictures on the same plate; and a great merit of this arrangement is, that both pictures can be taken at once. In fact, so great an advantage is this, that no objects which move rapidly can possibly be taken in any other way. The double instrument, called the "double-lens stereoscopic camera," (or erroneously, by some persons, the "binocular camera,") is therefore, in every respect, the most scientific instrument to employ for obtaining stereoscopic pictures.

A good form of the instrument, for taking the small pictures for the lenticular or cosmorama stereoscope, is shown in Figs. 8 and 9.

Fig. 8, scarcely requires explanation. When a stop is used, it should be put immediately in front of the first lens. Without a stop, instantaneous pictures could be taken in a good light. The tubes which carry the lenses can be moved backwards and forwards in focussing, by means of a rack and pinion in the sides of the camera. Either tube may be moved independently of the other. The front of the camera has two circular openings to admit the pencils which produce the images. These are covered and uncovered by the revolution of a circular plate, (see Fig. 9,) which has two corresponding openings, and turns about an axis in the centre of the front of the camera. At the bottom of this revolving plate is a heavy handle, which, by its weight, keeps the openings in the plate in a vertical position, and the holes in the camera covered. By a rapid semi-revolution of this plate, a nearly instantaneous exposure may be given to the pictures.

It only remains to add a few words with respect to the principal dimensions of the camera.

The equivalent focal length of the lenses should be five inches, and they should be five inches from centre to centre. This distance between the stations is a mean which will suit a very large class of subjects, including portraits and views, in which there are near as well as distant objects. The pictures are circular, four inches in diameter, and five inches from centre to centre. The positive prints, when cut and trimmed, are reduced to the usual size for the ordinary stereoscope, or, when exhibited as circular pictures, are suitable for the large cosmoramic stereoscope, the lenses of which are quarter lenses cut from a large one five inches in diameter. The glass plates suitable for this camera should be ten inches long by five inches wide. The slide should be a non-reversing slide, in which either the coated side, or the back of the plate, may be presented to the lens.

Fig. 8.

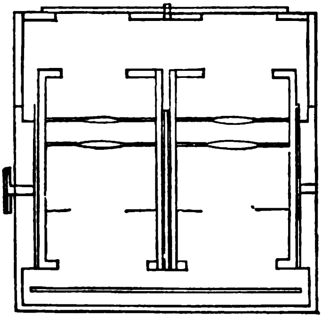
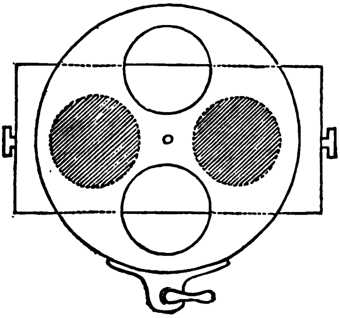


Fig. 9.



**Camphor.** The camphors are a species of concrete essential oils. They are essential oils which have become more or less oxidized and solidified. Light has great power in ozonizing oxygen in the presence of essential oils, and the oxygen thus changed, oxidizes either the oil or other substances, which may also be at the same time in contact with it. It is the presence of this form of oxygen, which gives to the essential oils their odour; for if non-oxygenized oils be distilled off quicklime in vacuo, the product is so far inodorous, that oil of lemons can scarcely be distinguished from oil of turpentine. Hence the effect of light in increasing the perfume of odorous bodies. The camphors pass by further oxygenation into organic acids, which will combine with oxides of silver or other metals, and these changes illustrate the effects of organic matters in photo-chemistry.

Common camphor is the produce of the camphor laurel of Japan and China. It has been added to gallic acid, to serum, to albumen, and other organic solutions, to preserve them from decomposition; to gallic acid when used in developing albumen negatives, to prevent "dulling" of the film, and to the salting solutions for paper, to produce richness of effect. Its anti-putrefactive power is probably due to its absorbing the oxygen which would otherwise act on the gallic acid or other matter. It is soluble in 1000 parts of water, but alcohol of S. G. 806, will dissolve more than its own weight.

**Canada Balsam.** This is a turpentine obtained from the *Abies balsamea*, which grows in Canada and the state of Maine; it is used to cement the lenses which form an achromatic combination, in order to diminish the reflections at the inner surfaces. Its colour is not found appreciably to stop the actinic rays when thus employed, though in photographing microscopic objects mounted in it, its antiactinism is very considerable. *See* "Transparencies."

**Cane Sugar.** The sugar obtained from the sugar cane. A small piece added to each ounce of the nitrate of silver solution in printing positives, is said to have the effect of giving a smooth velvety surface to the picture, and also of allowing the paper to be kept; for though, like other papers, it changes after a time to a yellow colour, this entirely disappears in the hypo-fixing bath. Sugar forms a combination with the nitrate of silver in excess, which keeps it on the surface, and is probably decolorized with greater facility than the compound which the nitrate forms with the ordinary paper sizing in the substance of the paper. It renders the paper sticky, and in our hands appeared likely to spot the negative and contract dust, without increasing the surface vigour of the impression. *See* "Sugar, and Preservative Processes."

**Canson's Paper.** *See* "Paper."

**Canton's Phosphorus.** Made by calcining oyster-shells in the open fire for half an hour, after which, the whitest pieces are mixed with one-third of their weight of flour of sulphur, and heated red hot in a closely-covered crucible for an hour. The phosphorescent appearance which this assumes in the dark is much exalted by exposure to the sun's rays, and this is the case with many phosphorescent bodies. This effect is independent of heat. *See* "Solar Phosphori, and Light."

**Caoutchouc.** Common india-rubber, the inspissated milky juice of certain trees growing in America and the East Indies. Various plate-holders, and other pieces of apparatus, are made in part or wholly of this material; and if it is to be brought into contact with nitrate of silver solutions, it should be remembered that the very flexible and elastic variety, called vulcanized india-rubber, contains sulphur, imparted to it in its manufacture. It is soluble in ether, chloroform, benzole, and some volatile and fixed oils. Naphtha also dissolves it, with the aid of heat. In some brittle black varnishes, where these solvents are resorted to, caoutchouc, in small quantity, is a useful ingredient.

**Cap of the Lens.** The brass, or, what is better, pasteboard cover, which is used to cover and uncover the lens at the time of exposing the sensitive plate to light.

**Capsules.** Small shallow basins made of berlin ware, platinum, &c., for evaporations, solutions, &c.

**Caramel.** Burnt sugar. It is soluble in water, and has been tried instead of honey, &c., in preservative processes. It was found to lessen the sensitiveness, but was less inclined to crystallization.

**Carbon.** An elementary substance appearing in a great variety of forms, of which the diamond is the purest and charcoal the most common. A stick of charcoal put into a solution of nitrate of silver and placed in the sunlight, will revive pure white silver around and adhering to itself. It has hence been said, that carbon, with the aid of light, can reduce silver in solution to the metallic state; but the reduction is due rather to the peculiar physical properties of carbon in certain forms, than to an ordinary chemical reaction. This effect of carbon rather resembles the catalytic action of spongy platinum.

CARBONATE OF AMMONIA. There are several definite hydrated carbonates of ammonia, but the usual commercial carbonate is a sesquicarbonate containing three atoms of acid to two of ammonia. By exposure to air, it becomes a bicarbonate. It is added to iodide of iron to make iodide of ammonium, but this is not the best method. It sometimes occurs in collodion iodized with this ammonium compound, and then its action in producing nitrate of ammonia in the bath must be attended to.

CARBONATE OF BARYTA. $Ba. O, C O_2$. An insoluble salt formed when soluble baryta compounds are precipitated by alkaline carbonates. Used by photographers in making iodide and bromide of barium.

CARBONATE OF LIME. $Ca. O, C O_2 = 50$. The most abundant compound in nature, comprising the marbles, limestones, and other rocks. Calcareous spar and statuary marble are used in the laboratory as the purest varieties. This salt will answer many of the demands of photography, as far as regards carbonates; as, for instance, for neutralizing the nitrate of silver, or hyposulphite of soda bath, or other acid solutions, and for estimating the strength of the acids employed as measured by the alkali that is necessary to saturate them. It is sometimes found in small specks in the surface of glass plates, and is best removed by nitric acid. It is an impurity in animal charcoal, and in many hard waters. It is insoluble in water.

CARBONATE OF POTASSA. $K O, C O_2 = 70$. This is a deliquescent, strongly alkaline, fusible salt. Its strong attraction for water renders it useful in dehydrating ether and alcohol, and it is otherwise of service in cleansing glass plates, as an antacid, in forming acetates, in forming carbonate of silver, and in reducing chloride of silver to the metallic state. It often exists as an impurity in bromides, iodides, chlorides, cyanides, and other salts of potassium, and is very generally employed in their manufacture. The carbonate of commerce is obtained from the ashes of trees and vegetables burned for the purpose, and is contaminated with chlorides and sulphates, which may be in a great measure got rid of by dissolving the crude carbonate in water, and evaporating till the solution is of the S. G. 1·52, when most of the impurities will crystallize out. When required quite pure for analysis, it is obtained by heating the crystallized bicarbonate to a temperature below redness, but sufficient to expel its water and half of the carbonic acid, dissolving the residue, and filtering.

Carbonate of Silver. $Ag. O, CO_2$. This is precipitated as a pale yellow insoluble powder, by adding carbonate of potassa to nitrate of silver. It blackens by exposure to light. It is formed and dissolves in small quantity in solution of nitrate of silver when a soluble carbonate is added to it to neutralize free nitric acid, and the small quantity taken up communicates to the solution a slightly alkaline reaction, which renders it necessary to add a drop or two of acetic acid to counteract the bad effect which the slightest alkalinity produces.

Carbonate of Soda. $Na. O, CO_2$. Manufactured for washing purposes in immense quantities, by the decomposition of common salt by sulphuric acid, subsequent fusion of the product with chalk and coal in a reverberatory furnace, and purification. This mode of making it adulterated, leaves it with a small quantity of chloride of sodium and sulphate of soda, but it is generally extremely pure. It is used in the same way as carbonate of potassa, and also in making nitrite of soda, for producing nitrite of silver, in removing the size from paper, in separating chloride of copper when chloride of gold is obtained from the standard coin, and in moderating the action of chloride of gold used as a toning bath.

Carbonates. The carbonates used in photography, when soluble, are all alkaline in their properties, owing to the weakness of carbonic acid, and this must be particularly remembered, not only when they are used, but also when the chlorides, bromides, iodides, cyanides, and hyposulphites, are employed, because they are all more or less adulterated with corresponding carbonates. When hard water, containing carbonate of lime, is used for making nitrate of silver solutions, the alkalinity produced must be removed, and pictures must not be washed in such waters immediately after going through solutions containing carbonate of soda, or the lime will be precipitated on the picture.

Carbonic Acid. $C O_2 = 22$. This gas is a very feeble acid, and reddens litmus paper but very little. Its effect as an acid, in retarding the action of light, or a developer, is almost inappreciable, but in nature it is itself decomposed by light in the leaves of trees and plants, which give off its oxygen and retain its carbon. The rays which effect this are the luminous or yellow rays of the spectrum: the chemical rays are much less active.

CARBONIZED PLATES. Copper plates have been evenly covered with hydrocarbon, in the form of finely divided powder, and, by exposure to heat, have been superficially converted into carburet of copper. These plates, covered with nitrate of silver and exposed to light under a negative, will receive an image in pure milk-white silver, but there is always too much tendency in the metallic plates themselves, to reduce the nitrate, to render the process available.

CARBURET OF SILVER. $Ag._2 C$; $Ag. C$; $Ag. C_2$. Silver will not only combine with organic matter composed of carbon, hydrogen, and oxygen, but also with carbon alone, and that in three proportions, forming a dicarburet, a carburet, and a bicarburet. The compound containing least carbon is formed by keeping fused silver in direct contact with carbon for some time; but the others are formed by reduction from compounds of silver with organic acids by means of heat. Now this reduction is sufficiently like the reduction of organic salts of silver by light, to be worth comparison. The carburet containing silver and carbon, atom for atom, is a yellow substance not affected by heat, and soluble in nitric acid. If the photographs which fade do so because the silver continues to undergo reduction, nearer and nearer to the metallic state, is the final yellow the residue of an organic salt from which sulphur, hydrogen, and oxygen have departed, and of which the carbon and silver alone remain? Or do sulphur and carbon both remain?

CARRAGEEN. Irish moss, *Chondrus crispus*, or *Fucus crispus*. This is a kind of sea-weed, while Iceland moss, *Cetraria Islandica*, is a lichen, Both have been resorted to in photography, on account of the jelly which they contain. The carrageen contains 80 per cent. of vegetable gelatine, 10 per cent. mucilage, and 10 per cent. of chlorides, iodides, and bromides. It has been used 30 grains to the pint of water as a first preparation in the wax paper process. It is not precipitated by nitrate of silver, and therefore it may be supposed not to exert so much modifying power in that process as albumen does in others; and indeed its action in waxed or other papers is of little moment, so far as the image is concerned. The solution of *Chondrus crispus* must not be confounded with that of chondrine, which is derived from animal sources. *See* "Organic Matter."

**Caseate of Silver.** Caseine is the cheesy matter of milk. It combines with oxide of silver in the same way as albumen, and forms an insoluble organic salt of a white colour, which becomes brick-red in the light. It therefore powerfully influences reduction of the silver salts in photo-chemical operations. The white salt is called by some the caseate of silver.

**Caseine.** The principle in milk which produces cheese. It greatly resembles albumen. Like it, it is held in solution in the milk by the alkali with which it is combined, and it is coagulated and precipitated by acids. Its action on nitrate of silver, and in photographic processes, also closely resembles that of albumen. Vegetable caseine, which exists in the gluten of flour, acts in the same manner, and hence flour paste is a much more powerful body in calotype, &c., than the starch with which French paper is sized, or even than the animal gelatine of some English papers. It is the valuable part of the serum, or whey, used in photography, and therefore that liquid should be prepared so as not to be entirely free from it, but to contain a definite quantity. Caseine dissolved in dilute ammonia will form a solution which will coat a plate like collodion or albumen, and it has already been used in this manner. Its properties must be intermediate between those two fluids, since it has the combining power of the albumen, and yet does not form a film so hard or difficult of development as that substance; and a more ready development always implies an increase of sensitiveness.

**Catalysotype.** A calotype process, in which the paper is first prepared with syrup of iodide of iron, instead of the ordinary iodide of potassium. As the picture developes itself after exposure by merely keeping the paper moist without using the usual gallic acid developer, it was supposed that light set up a "catalytic" action on the silver salt, which then operated on the iron salt to produce a picture. The truth was, that when the paper was excited on the nitrate of silver, protonitrate of iron was formed by the same decomposition which produced iodide of silver, and this protosalt is a still more energetic developer than gallic acid. The process is not good, because the solution of nitrate of silver used for exciting is in a few hours quite blackened by the iron, and the iron-syrup is itself very inconstant in its composition: but, with smart manipulation, and fresh solutions, it is extremely quick.

Catalytic Action, (καταλυσις, dissolution.) The following are a few instances of what has been called catalytic action. Clean surfaces of platinum attract hydrogen and oxygen gases so powerfully, that, without combining with them in any way, it draws them into such close contact with itself, and with one another, that they unite and form water; platinum black will absorb in this way, without chemical union, 250 times its volume of oxygen. Charcoal newly burned and introduced into a mixture of oxygen and sulphuretted hydrogen, causes their combination with such force, that while it remains chemically unchanged, it nevertheless becomes ignited, and the gases explode. When a pound of starch is digested, and kept simmering for a few days, with six or eight pints of distilled water rendered slightly acid by two or three drachms of sulphuric acid, the sulphuric acid, though itself remaining unchanged, causes the starch to be converted into sugar. A ferment introduced into solutions of sugar will cause the sugar to be decomposed into alcohol and carbonic acid, without itself combining in any way with either. Water is an oxide of hydrogen which is capable of taking another atom of oxygen, and becoming a binoxide, still retaining the form of water; but a piece of gold put into it will suddenly decompose it without becoming itself oxidized. When chlorate of potass is heated to cause it to give off oxygen, it is found that the gas is much more freely liberated when binoxide of manganese is also present, though chemically it takes no part in the decomposition, nor is itself deoxidized. In all such cases where a body effects chemical changes in other bodies, itself remaining unchanged, this action of presence is called catalytic action. It has been supposed by some that light, when it acts on salts of silver to produce an invisible impression, modifies the salt in some way to communicate to it catalytic properties. The most probable account of such an effect would be, that the chlorine undergoes some modification similar to that which oxygen in certain processes undergoes when it becomes ozone, without losing its chemical identity. Light has been shown by Professor Schönbein, in certain cases, to produce this effect on oxygen, and in all cases of catalytic action it may be that the catalyser, if we may use that term, renders allotropic one or more of the elements with which it comes in contact. This notion of the *modifying* power of the light is not *opposed* to the theory which supposes that a gradual reduction of metal takes place in the camera, though in such small quantity as to be inappreciable, because the modifying power may be the cause of the reduction. No doubt the development of the image commences at a point which our eyes cannot reach, and it is of no importance whether that commencement takes place in the camera or the dark room.

**Caustic.** (Καυσις. burning). Chemical substances which destroy the vitality of any part of the body, or produce effects like burning, are called caustic. The name is generally applied to certain alkaline oxides and acid salts, which destroy animal structure. The most commonly used caustics are nitrate of silver, and potassa. The fixed alkalis and earths are all caustic, as lime, baryta, potassa; also such salts as chloride of zinc and chloride of gold.

**Caustic Ammonia, Potassa, Lime,** &c. *See* "Ammonia," &c.

**Centigrade Thermometer.** This is the thermometer generally used on the continent, and is so called from centum a hundred, because the space between freezing and boiling water is divided into 100 degrees. The thermometer used in England is Fahrenheit's, where freezing water is marked 32°, and the boiling point 212°. In the two scales, therefore, 32 and 0, 41 and 5, 59 and 15, 68 and 20, 86 and 30 are corresponding points. To convert centigrade into Fahrenheit, multiply by 9, divide by 5, and add 32.

**Centigramme.** A weight often introduced into England with French formulæ. It is the hundredth of a gramme. A gramme is equal to 15·432 grains troy, and a centigramme to ·1543 gr.

**Centilitre.** The hundredth part of a litre, or of 35oz. 2dr. 11min. English fluid measure.

**Centimetre.** The hundredth of a metre or of 39·7 inches English; it is nearly $\frac{4}{10}$ or $\frac{3}{8}$ of an English inch.

**Ceroleine.** A principle in bees' wax, soluble to a small extent in alcohol. The alcoholic solution when iodized, has been used as a substitute for the wax itself in the wax paper process. Its effect as organic matter is rather stronger than that of wax; it does not, when introduced with alcohol, impede the action of light and of the developer so much, and is more easily manipulated; but it requires the paper to be re-waxed. Ceroleine also gives greater intensity when bromide or chloride of silver is added to the iodide, than when the latter is employed alone. It has been added to collodion, and the small quantity which dissolves in the ethereal mixture, will prevent, by its adhesive character, the cracking which is caused by too large a quantity of water. The proportions for preparing paper are—

Solution of wax in alcohol, S. G. 817, (90 grains to the pint of 20 oz.)—30 fl. oz.

Saturated solution of iodide of potassium in alcohol, S. G. 840—1 fl. oz.

CHARCOAL. *See* "Animal Charcoal."

CHEMICAL ELEMENTS. Those substances are called elements, which no known chemical operations will reduce to simple forms. *See* "Tables."

CHEMICAL EQUIVALENTS. Every simple substance, and every compound substance also, has what, in chemistry, is called its equivalent number; thus, 1 is the equivalent number of hydrogen, and 8 is the number belonging to oxygen; nitrate of silver has the equivalent number 170, and hydrosulphuret of ammonia the number 34. These numbers express the proportions by weight, in which they combine with or are completely decomposed by each other, and these proportions are always constant. One grain of hydrogen, for instance, will always take 8 grains of oxygen to form water, and 34 of sulphide of ammonium will always throw down the whole of the silver from 170 of nitrate of silver. It is easy therefore, from a table of these numbers, to see at a glance how much of any substance is required for any chemical operation. *See* "Tables."

CHEMICAL FOCUS AND CHEMICAL RAYS, CHEMICAL SPECTRUM. The rays which, in a compound pencil of white light, produce chemical changes with the greatest force, are not the red, yellow, or green, but the blue, violet, and even some invisible rays, and these, after the pencil has been refracted by a lens, do not come to the same focus as the more luminous rays. The point, therefore, of their coincidence, is called the *chemical* focus, and the other the *luminous*; the blue, violet, indigo, and invisible rays, are called chemical rays of light, and those rays of the sun which produce chemical changes by their heat, are called chemical rays of heat. *See* "Light." When light is decomposed into its coloured rays by being passed through a glass prism, it is, when thrown upon a white screen, received as an oblong figure called the solar spectrum, and that portion of it which acts chemically, is called the chemical spectrum. The impression which this makes upon a piece of sensitive paper, is also sometimes distinguished as a chemical spectrum.

Chemistry of Photography. It has been said that light does not fall on any body in the universe, on which it does not leave traces of its passage, and that it cannot be absorbed or reflected, without in some way modifying the structure and properties of the substance on the surface of which it struck. . All the effects which light thus produces are properly the subjects into which photography inquires. But it is impossible here to do more than make a general inquiry as to how light acts in common and easy cases, and endeavour to apply the information thus acquired to the explanation of the usual photographic processes. It will be easy for the reader to adapt the same principles to the phenomena of photo-chemistry in general.

The most simple case of luminous action will be mentioned first, because, while it is less complex than any other, it is also a striking type of the whole class of decompositions and syntheses effected by the solar radiations. The element chlorine is carefully isolated from all other substances, and exposed to the sun's rays. No apparent change takes place in it: its colour, volume, density remain the same; but it was observed by Dr. Draper, that in such circumstances it undergoes a remarkable modification. For, whereas before solarization, it had no power to combine directly with hydrogen, it combines with it after that event with extreme readiness, even in the dark. No other element, when alone, has yet been found to experience this kind of change in the light to the same extent, and this fact, therefore, places chlorine in the highest rank as a photographic re-agent: the increase of affinity of chlorine for hydrogen in the light, and of bodies of the same class, as chlorine, for substances resembling hydrogen in their chemical properties, appears to be the thread which runs through all photographic operations, and the basis of the art.

The effect produced on chlorine when alone, naturally leads to the expectation that a very decided action will take place, if hydrogen also be present at the time of exposure. Accordingly, we find a mixture of hydrogen and chlorine gases placed in the sunshine, immediately combine with such force as to produce an explosion, and the weakest daylight will produce a perceptible amount of condensation. This mixture has been proposed as an actinometer. The hydrogen and chlorine united, form hydrochloric acid, and the quantity formed in a given time, is in direct proportion to the intensity of the actinic force existing at the time in the luminous ether. No change has yet been found to be effected in hydrogen by solar action, and it may be that the action is confined entirely to the chlorine.

It is not necessary that the hydrogen should be in the elementary state to be capable of photosynthesis with chlorine. A great number of organic and other compounds of hydrogen, are decomposed by chlorine in the light. A solution of chlorine in water, for instance, when exposed to the sun, is speedily decomposed, for hydrochloric acid is formed, and oxygen given off to the atmosphere. $HO + Cl. = H\,Cl. + O$. The action which thus takes place in hydrogenous bodies, in the presence of chlorine, is one of two. If the compound body contain water, the hydrogen of this water is removed by the chlorine, as hydrochloric acid, and the oxygen unites to the remaining elements of the compound to form a new substance. But if the compound substance contain no water, hydrogen is removed as before, and forms hydrochloric acid with the chlorine; but for every atom of hydrogen thus abstracted, an atom of chlorine is substituted to supply its place. Thus, in the case of alcohol, $C_4\,H\,O_2$, what may be represented as a binhydrate of quadrihydrocarbon, or $C_4\,H_4$, $2\,HO$, that is, one atom of quadrihydrocarbon, and two of water, when chlorine reacts upon it, the first effect is to take away the hydrogen of the water, and leave the two atoms of oxygen to unite with the $C_4\,H_4$, and form acetic ether; but when the water is thus decomposed, hydrogen is no longer removed, except by the subtitution of chlorine to fill up the gap. One atom after another is replaced in this manner by chlorine, with the production of as many different compounds as there may be atoms of hydrogen exchanged, until finally but one atom of hydrogen keeps its place, and the resulting substance is chloral ($C_4\,H_1\,Cl._2\,O_3$). Chloracetic acid is another remarkable instance of this change of substance by substitution. This compound was discovered by Dumas. It is formed by introducing a small quantity of concentrated acetic acid into bottles filled with dry chlorine, and exposed to the direct sunshine. White vapours are soon formed, and the chlorine disappears. In fierce sunshine the action is sometimes so intense as to cause explosion. The next day crystals are found in the bottles, of chloracetic acid; and, on opening them, vapours as seen to escape of hydrochloric acid, carbonic acid, and chlorocarbonic or phosgene gases. In the crystals it is found that the whole of the hydrogen of the anhydrous acetic acid has been replaced by chlorine: thus $C_4\,H_3\,O_3\,H\,O$, has become $C_4\,Cl._3\,O_3$, $H\,O$. Chlorine also, in the presence of chloride of ethyl ($C_4\,H\;\;Cl.$), placed in the direct light of the sun, will remove two of the five atoms of hydrogen by forming hydrochloric acid, and at the same time put two of its own atoms in their place. An intermediate compound is first formed, when single atoms only are exchanged, and one atom of hydrocholoric acid only produced. So far is the mere fact of the hydrogen being in combination, from preventing its union with chlorine in the light, that in some instances the hydrochloric acid is formed with great violence. Thus, when light carburetted hydrogen or marsh gas ($C\ H_2$) is mixed with chlorine in the proportion of one volume of the former to three of the latter, even the diffused light of day is sufficient to cause a violent explosion. The vessels are broken, hydrochloric acid formed, and carbon, and chloride of carbon deposited. Of course the difficulty of removing the hydrogen increases with the strength of the affinity which binds together the compound in which it exists, but no affinity is strong enough to prevent it altogether; water, which is as stable a hydrogen compound as any, is easily decomposed by chlorine and sunshine.

Nor is it necessary, it may be further remarked, that the chlorine, any more than the hydrogen, should be in the elementary state in order to produce its usual reaction with hydrogen in the light. Both the hydrogen and the chlorine may exist in combination in compounds more or less stable, in both of which the affinities may be far from weak, and yet the light may have the power of causing their mutual decomposition. Thus, the sub-chloride of sulphur will be gradually decomposed by water in ordinary daylight, and tetrahedral crystals of sulphur may be thus obtained. The compounds of phosphorus, silenium, carbon, silicon, and perhaps sulphur with chlorine, decompose water, and hydrogenous liquids in the same manner. The terchloride of nitrogen is a substance very dangerously explosive in the presence of hydrogenous and other combustible bodies. A small globule of this under water causes a tremendous explosion by mere contact with a drop of fixed oil, which disperses the water with great violence, and emitting a momentary flash of light breaks the containing vessel into atoms. But these compounds of chlorine are not the most stable of the class. As the affinitics increase in strength, the difficulty of overcoming them by hydrogen increases. The alkaline and earthy chlorides are not decomposable in this manner, nor are the majority of metallic chlorides. Those only appear to be thus affected which are very easily reduced to the metallic state, or which pass without great difficulty from a higher to a lower state of chloridation, as from bichloride to chloride, or from chloride to sub-chloride, as the chloride of silver.

These are the principal cases in which chlorine is combined with hydrogen by the action of light. But hydrogen, though by far the most important, is not the only body with which chlorine has greater power of combining in the light than the dark. The element approaching nearest to it in this property is carbon. It requires, previous to its combining with chlorine, to be like hydrogen in the gaseous state, or else in the state in which it exists in organic compounds. These two bodies are thus associated together universally in all animal and vegetable bodies, and are also acted upon by chlorine in the same manner, but in very different degree. When mixtures of olefiant gas and chlorine ($C_2 H_2$ and Cl.), or marsh gas and chlorine ($C H_2$ and Cl.), are exposed to light, both the hydrogen and the carbon enter into union with chlorine, and in the first mixture a triple compound is formed, unless great excess of chlorine is present. The results in both cases are hydrochloric acid and chloride of carbon. The chlorided compounds of carbon are either solid or liquid, but of hydrogen gaseous. It might be supposed that it was the hydrogen which in these cases determined the combination of carbon and chlorine, but the fact that the hydrogen does not take the whole of the chlorine when there is not enough to saturate it, shows that this is not the case; and instances occur where no hydrogen is present, and where still the carbon and chlorine are induced to unite by solar action. Equal volumes of chlorine and carbonic oxide gases (Cl. and C O) exposed to ordinary daylight, unite very gradually, but in the sunshine very quickly, and in the dark not at all. It was on account of its mode of formation, called by Dr. Davy, phosgene (φως, light, and γεννaω, to produce). Carbon also, existing in alcohol, and in many organic compounds, has a great tendency to unite with chlorine, and this tendency is favoured by the action of light. Phosphorus, sulphur, boron, selenium, silicon, would seem, from many reactions, to be similarly attracted by solarized chlorine, though in a degree not equal to hydrogen and carbon; and this property, as affecting them, is scarcely resorted to in photography.

But is chlorine separated from any of its compounds by the influence of light? Its union with hydrogen and carbon, as produced by that agency, is sufficiently demonstrated by the preceding experiments. Are its compounds ever decomposed by the same agency? In the presence of hydrogen or its compounds, yes; otherwise it seems probable that they are not. This is opposed to the popular opinion on this subject. Chloride of silver, bichromate of potass, citrate of silver, ammonio-tartrate of iron, and other such preparations, are constantly spoken of by photographers as if they suffered decomposition merely as the effect of solar light. The light is said to loosen the affinity of chlorine and silver for each other, to have a deoxidizing power, to be a destructive agent. Of course, it would not be more strange that it should lessen affinities than that it should exalt them, and the question is one entirely of experiment. It does not appear, however, that any experiment has yet been recorded which proves that the change produced by light is of this kind; while the experiments made by Seebeck and Scheele, with a direct view to determine the point, are strongly conclusive against it. Chloride of silver, covered, in a stopped phial, with sulphuric acid, was found by Seebeck to remain uncoloured in the sun's rays; taking the stopper out was sufficient to cause its discoloration, as was also the addition of water to the acid. Scheele's idea was, from his experiments, that chloride of silver was not decomposed by light, except in the presence of hydrogen or its compounds. Chloride of silver in the dark is not discoloured, even when pure dry hydrogen is present, but is instantly in the light. Compounds of chlorine, much less stable than the silver salt, are not decomposed by light in this manner, though they are very quickly changed when hydrogen in any form is present. Such bodies appear to be very stable when perfectly protected from all combustible substances which can take the chlorine. Even the much stronger current of electricity, produced by a galvanic circle, appears to have no power of separating elements in such a direct and abrupt manner. We are not without indications in our ordinary photographic operations, which show that the elements which are concerned in the decompositions must be balanced with tolerable nicety to allow the luminous ether to interfere with them, and such a compound as chloride of silver would be too stable to allow its affinities to be overcome by so weak a force. The affinity of chlorine for silver is not much weaker than the attraction of hydrogen for chlorine, or for oxygen, if we may judge by their mutual reactions, and would therefore be as likely to resist the action of light as water itself. The only example produced by chemists, of decomposition taking place directly by light, so far as we are aware, is that of chlorous acid. Chlorine is here (Cl. O) associated with an element so nearly resembling itself in its relations, that it is difficult to say which is the negative and which the positive. They replace each other in many compounds: their affinities for other bodies are of equal strength, and directed to the same elements, and their attraction for each other in this compound so slight, that the warmth of the hand is often sufficient to cause their dissolution. It is said that chlorous acid is not changed by several hours' exposure to daylight, but that a few minutes' sunshine decompose it without explosion. But it is more probably the heat of the sun's rays which effect this change than the actinism, since a slight elevation of temperature will decompose this gas with explosion. As hydrogen in many views resembles the metals, analogy would suggest that the effect of light would be to increase the affinity of chlorine for silver, rather than diminish it. For these reasons it seems necessary to regard the presence of hydrogen, or some such substance, as requisite in photal reactions. The nature of the hydrogenous compounds must therefore be calculated, in all photographic preparations, and in all reasonings on the chemistry of the processes.

Hitherto, for the sake of simplicity, no mention has been made of any photo-sensitive element but chlorine; yet oxygen, bromine, iodine, cyanogen, and others, might have been, at the same time, adverted to. Neither of these is capable of uniting, as chlorine does, with gaseous hydrogen directly when exposed to light: they are, therefore, weaker reagents in those changes which are determined by solar radiations; but from other indications we conclude that their action on combustible bodies, which contain combined hydrogen and carbon, is still very powerful when light falls upon them. Thus, the drying oils, as they are called, confined in a vessel with pure oxygen, at first scarcely absorb any in the dark, but, exposed to strong light, they are speedily oxidized and converted into gelatinous substances which do not stain paper. As in the case of chlorine, substituted for hydrogen, which we mentioned above, the oxygen here removes carbon in the form of carbonic acid, and at the same time replaces it with oxygen; no water is given off, though probably formed in the oil itself. A similar though weaker action takes place with other fat oils. Fats and butter absorb oxygen in the light, and become acid. The essential oils absorb oxygen, and this absorption is much more actively carried on in the light, and is the reason of their being odorous. During the oxidation, some give off carbonic acid and a small quantity of hydrogen, become more and more soluble in alcohol, and more solid, and are partially converted into camphors or resins: others give hydrogen to form water with the oxygen, which water unites with the remaining elements, to form solid hydrates. Bitter almond oil, in the air and sunshine, absorbs two atoms of oxygen, and is converted into solid hydrated benzoic acid ($C_{14} H_6 O_2 + O_2 = C_{14} H_5 O_3$, HO). In the similar case of chlorine, bitter almond oil and light, $C_{14} H_6 O_2 + 2$ Cl. $= C_{14} H_5 O_2$ Cl. + H Cl., but the hydrochloric acid (H Cl.), instead of remaining in the compound as the water (H O) does, is liberated. Oil of cinnamon is decomposed in precisely the same manner. Gum guaiacum, in the light, absorbs oxygen and changes colour to green. The bleaching and the coloration of oils by light, are attributable to the same species of reaction. In the photographic processes with bitumen, this property is taken advantage of, and in the photolithographic processes generally. Carbon, in certain of its organic forms, has also the property of uniting with oxygen in the light, and in many of the gradual changes which light operates in complex organic substances, both the carbon and the hydrogen which they contain are oxidized. Bromine and iodine unite directly with carbon and hydrogen, existing in the gaseous state in the form of olefiant gas, when exposed to the sun's rays, though they do not appear to have any such power on isolated hydrogen or carbon. They are also both capable of entering like oxygen and chlorine, by a process of gradual substitution, into numberless organic compounds of hydrogen, carbon, and oxygen: and an inquiry into the exact interference of light in these cases, constitutes the real field of scientific photography. Whenever chemists speak of the *protracted or gradual* effects of these electro-negative bodies upon others which are more electro-positive, the influence of light is to be suspected; and their mutual reaction, when recently prepared, and when they have never seen the light at all, ought to be in such cases examined. The processes of fermentation, putrefaction, spontaneous decomposition, and change of form, and spontaneous combustion, and other changes often spoken of as if they were effects without causes, should also be studied in their relation to actinic phenomena.

The other imponderable fluids, as well as light, have the power of increasing the affinities of chlorine and hydrogen, and of their respective congeners. Thus, hydrochloric acid may be formed by passing electric sparks through the mixed gases, or by subjecting them to a certain degree of heat, and both these are capable of effecting combinations which light is too weak to produce. These same agents are even found, where they exert different degrees of force, or in different circumstances, to have both the faculty of uniting elements, and of decomposing the compound which their union forms. Thus, hydrochloric acid may be decomposed into its elements by the electric spark as well as formed by its agency. And the like effect has been observed in photography, to attend the action of the actinic rays, and has been called "reverse action of light."

From a comparison of the effects produced by these fluids upon the two classes of substances which have been spoken of above, in different circumstances, we learn that the order of affinities, as far as relates to the "sensitiveness" of the elements, is as follows:—

Chlorine
Oxygen
Bromine
Iodine
Fluorine
Cyanogen
Hydrogen
Carbon
Phosphorus
Sulphur
Selenium
Boron.

This order is the same for electricity, light, and heat alike. The metals have not been classed, because if; as analogy would intimate, the affinity of chlorine for them is increased by light, and not diminished, as some suppose, this has not hitherto been taken advantage of in photography. If we wish to form a table of hydrogen and carbon compound bodies, arranged in the order of their affinity for chlorine, &c. in the light, some modification of it would be necessary for each element, in accordance with the nature of the decomposition which would take place.

With respect to the *mode* in which light operates in modifying the chemical relations of bodies, we are almost entirely in the dark. It has been disputed in some cases, whether actual decomposition is produced, or only a change in the arrangement of the constituent atoms; but it is clear that a molecular change must first be induced by light, and that this must end in decomposition. The precise moment when such decomposition commences is beyond our perception, and is not, in any case, necessary to be known. What the nature is of this molecular modification, is the interesting question. With respect to oxygen, we know that it is capable of existing in two forms—the active or allotropic form found in ozone, and the usual and less active form. Allotropic oxygen is often formed from ordinary oxygen by electricity, and recent experiments have shown that it is also formed by light, in those cases where bitter almond oil, and other such bodies are present. It is therefore fair to conclude that light acts on the bodies which resemble oxygen in a like manner, and the chlorine, which has been altered in its degree of activity by solarization, will be active or allotropic chlorine. And so of the rest. Bodies like hydrogen, combustible hydro-carbons, and phosgene gas, are so remarkable for their high refractive power on light, that Newton was led to suppose that the diamond was combustible merely from its index of refraction. Some essential oils and hydro-carbons can only be distinguished by a peculiar power of rotating a polarized ray of light to the right or to the left. These, and other like phenomena, would lead us to suppose that the action of light is to polarize the elementary atoms, and that their different properties are the effects of their polarity. A change of polarity in one element in a compound would immediately affect the whole, and might lead to its decomposition in the presence of a second body, or to the assumption of a different arrangement of its own elements if isolated. In either case the result would be a distinct chemical change. But light may perhaps, without producing an actual change of polarity, set up in certain cases a vibratory action among the particles themselves, similar to the regular vibrations produced by sound in sonorous bodies. This kind of action is sufficient to account for the phenomena observed in the formation of images by the condensation of vapours, as in the experiments of M. Möser. The condensed vapours then arrange themselves in the lines of vibration, just as in the figures of Chladni, minute solid particles arrange themselves on the sonorous surface.

The facts, therefore, which are established by experiment, and which must explain for us the formation of photo-chemical images, are—

First, The increase of affinity in the light of chlorine, oxygen, bromine, and iodine, for hydrogen and carbon.

Second, The regular decomposition which occurs in certain cases in consequence of this increase, capable of being represented by chemical formulæ.

Third, The gradual and progressive nature of this decomposition.

It remains to apply these to the explanation of the two processes to which all others used by photographers may be referred

### I. Sun-printing.

### II. Development Printing.

I. *Chemistry of Sun Printing.*—Printing on paper prepared with chloride of silver may be taken as an example. This paper is first prepared with a soluble chloride of sodium, barium or ammonium; it is then brushed over with a solution of nitrate of silver strong enough to decompose the whole of the chloride and leave an excess of nitrate. $Na.\ Cl. + Ago.\ No_5 = Ag.\ Cl. + Nao.\ No_5 + Ago.\ No_5$. The paper now contains (1) chloride of silver, (2) moisture, (3) nitrate of silver, (4) vegetable fibre, (5) starch or gelatine in the form of sizing, and lastly, nitrate of soda, which, however, produces no effect appreciable in the results. As to their separate influence, it may be said in general terms, that the chloride decomposed by light and moisture gives a feeble violet image, that the nitrate of silver strengthens it and somewhat darkens the tone, and that the vegetable fibre and size, but especially the size, give a redder and warmer tone to the colour, with more vigour and greater transparency. What is the chemistry of these effects?

First, as to the chloride. Some have supposed that the chloride is reduced to the metallic state by the entire removal of the chlorine; others, that the silver loses all its chlorine, but takes oxygen; others, that it loses half its chlorine and takes oxygen to supply its place, becoming a mixture of sub-chloride and sub-oxide; and others again, that it loses half its chlorine without taking oxygen. It seems to be a sufficient objection to the idea that in the reaction the silver is oxidized, that oxide of silver, in the presence of water, is reduced to the metallic state by light, and that the violet colour is not at all indicative of the presence of oxide or sub-oxide, for of these oxides one is brown, and the other black. The doubt, therefore, must lie between the reduction of chloride to the metallic state, or to the state of sub-chloride. The chloride of silver reduced to the metallic state by hydrogen in the ordinary methods, is of a dull grey colour, in no degree resembling the violet compound produced by the sun's rays acting on it, but, on the other hand, the sub-chloride of silver which is formed by immersing silver plate into a solution of per-chloride of copper or iron is of a deep violet tint, which, when another atom of chlorine is given to it by an aqueous solution of that gas, becomes white. The affinity of chlorine for silver is about equal to its affinity for hydrogen, if we may judge by experiments on them in a heated state; for red-hot silver will decompose hydrochloric acid, and red-hot chloride of silver will give up its chlorine to hydrogen passing over it. When, therefore, chloride of silver and water act on each other in the light, if the silver be reduced to the metallic state, the light must be powerful enough to decompose water, to prevent the oxidation of the silver, and to cause the hydrogen to remove the chlorine entirely from the salt, by the superior affinity for it in those circumstances. But this is scarcely in accordance with the known power of light in other similar reactions. And, as the metals which have two degrees of chloridation are known to part with one atom of chlorine much more easily than with both, we conclude the reduction to be to the state of sub-chloride only. $2\ Ag.\,Cl. + Ho. = Ag._2Cl. + H.\,Cl. + O.$ It is doubtful whether the atom of oxygen is immediately liberated and escapes into the air, for experiments with the iodine test for chlorine indicate its presence; it would therefore seem that, as in the electrolysis of water, the liberated oxygen often unites with the water to form peroxide of hydrogen, so in photolysis, the atom of chlorine sometimes remains attached to an atom of water as oxychloride of hydrogen, until set free by other causes.

The action of nitrate of silver is next to be considered. Its own decomposition by the organic matter of the paper will be examined in the next paragraph, with the paper itself; here we are concerned with the darkness which it adds to decomposing chloride of silver when no such matter is present. It will be found, if chloride of silver is precipitated from an excess of nitrate and exposed to the sun, that it darkens more than if there be no excess of nitrate in the solution. Pure chloride of silver itself is so perfectly opaque, that after very prolonged insolation it is only superficially decomposed, and immediately beneath the surface remains white: the colour is therefore too feeble to produce an effective photograph. This is the case when organic matter, however active, is present, and occurs with all kinds of papers, albumen as well as others, when there is no free nitrate. Organic matter seems to have no action on the chloride in this case; and the reason of this is doubtless to be found in the solid and intractable state in which they coexist, for in processes by development where the active organic matter is in solution its influence is very perceptible. The reason why nitrate of silver, added to the simple chloride, increases its darkening power, would appear to be that the hydrochloric acid formed by the light, precipitates from the nitrate new chloride continually upon the surface, which again suffers partial decomposition and renewal. In this manner a larger quantity of the violet salt will be formed than if no nitrate assisted in its accumulation.

But the nitrate of silver also modifies the colour and vigour by its specific reaction with the fibre and size of the paper. Cotton and linen fibre have both an affinity for many metallic oxides, alumina, oxide of iron, oxide of tin, &c., and among others for the oxide of silver; this affinity is sufficient to cause a decomposition of nitrate of silver in the light, though the light, unaided, has no power to decompose that salt, either in the solid state or in solution. The same solution of nitrate of silver which would of itself remain clear and bright for an indefinite period in the sun, will be very quickly reduced by light when in contact with a piece of Swedish filtering-paper or pure cotton wool. The oxide of silver combines with the fibre, and the nitric acid is set at liberty as may be perceived by its smell. The warm brown oxide therefore mixes, and perhaps combines with the subchloride, to intensify the deposit, and at the same time render the colour less cold and slatey. The organic matter with which the paper is sized is still more efficient in these respects, and so are the albumen, serum, and other substances with which papers are often purposely imbued. The principal classes of organic matter are, the lignines, the starches, the gums, the sugars, the gelatines, the proteiniferous bodies, the neutral and acid principles of fats, essential oils and liquid hydro-carbons, the resins and camphors, and the vegetable acids. These include an almost infinite variety of substances all varying in their behaviour in photographic processes. In sun-printing their action does not appear to depend upon the chlorine, combining with their elements in the light, but entirely on their power of forming compounds with the elements of nitrate of silver. All appear to possess this faculty in some measure or other. Generally they form soluble compounds with the alkalis, and insoluble ones with lime, baryta, and silver. Those which do not combine with oxide of silver to form an insoluble organic salt, do not produce so marked an effect in printing as those which do. Lignine, therefore, and starch, and even gelatine, are not so efficacious in giving warm, vigorous images as those bodies which contain proteine, such as albumen, caseine, and emulsine, but they require less after treatment to produce the blacks and purples, which are in general request. For this reason the French papers, prepared with starch, are by many preferred to the English, sized with gelatine and resin; and for the same cause, prints on albumenized paper are very red and difficult to tone. Sun-printing is thus a double reduction, where a violet subchloride and a red organic subsalt of silver are formed simultaneously, the resulting picture partaking of the colour and properties of both. That the red salt is a salt of the suboxide, as the violet is a subchloride, is shown by the fact that when citrate of silver is subjected to the action of hydrogen at the temperature of 212°, the protoxide contained in that salt loses half its oxygen, and a red brown salt is formed, just as when the citrate is decomposed by exposure to light. In both cases the hydrogen present removes half the oxygen. Many other organic salts of silver, according to Professor Graham, comport themselves in the same way when heated in hydrogen. Another proof is found in the fact, that the subsalt formed by hydrogen is soluble in water to some extent, giving a brownish solution; and so are the impressions on our albumenized and other papers weakened by the solvent action of water, especially when warm. It might at first sight be supposed, that since these organic salts of silver are thus easily decomposed by light, while the corresponding salts of lead and other metals are not so affected, that the silver was in some way the element acted upon by the light, and that the decomposition was not determined by the hydrogen and oxygen attracting each other. But the difference between lead and silver in these cases is probably found in the different condition of their oxides, the lead having no tendency to part with half its oxygen, as the silver does. Other metals which have two oxides, chlorides, &c. behave many of them like silver in this respect; for example, the ammonio citrate of iron, salts of the sesquioxide of uranium, the ferrosesquicyanide of potassium, the bichloride of mercury, and others. It may be that the second atom of chlorine or oxygen exists in these compounds in its allotropic form, and that therefore its removal by light is possible, whereas the removal of the second atom by the same means is impossible.

The chloride of silver is the only silver salt employed in sun-printing on paper. The bromide and iodide cannot be so used, on account of important differences in their chemical relations. If a paper, prepared as the chlorided papers in all respects, except the substitution of iodine for chlorine, be exposed to light, it is found impossible to get beyond a feeble grey or drab-coloured impression. The chemistry of this change is more obscure than that which occurs with chlorided surfaces. The following is a plausible explanation. Pure iodide of silver, exposed in the dry state to the action of the atmosphere and light, remains unchanged, and is not reduced to the condition of subiodide, as might be expected. Calotype papers, which have been prepared either by what is called the double or single process, may be thus exposed without change, for any period, to sunshine, but similar chlorided papers are immediately discoloured. Well-washed iodized collodion plates are equally incapable of receiving any visible impression; and, so far as any actual decomposition is concerned, pure moist iodide of silver may be pronounced insensitive to light. This seems to confirm very strongly what has been said respecting the mode in which the removal of half the chlorine of chloride of silver is brought about; for if the light acted *immediately* on the elements of the compound to separate them, it ought *à fortiori* to decompose iodide of silver where the connecting affinity is weaker. But if it be allowed that an atom of water must intervene, then it is plain why iodide of silver is not affected by the solar rays. Iodine dissolved in water and exposed to light, has not the power to overcome the more powerful affinity of hydrogen for oxygen, but on the contrary, a solution of hydriodic acid exposed to the air gives up the hydrogen of the acid to the oxygen of the atmosphere and sets the iodine at liberty. The great difference, therefore, between chlorine and iodine lies in the fact that the former has a power of liberating oxygen from water in the light, of which iodine is destitute.

When, therefore, papers prepared with iodide of silver and nitrate of silver darken in the sunshine, an idea might be entertained that the darkening proceeded from the nitrate only; but this would not be correct, because papers imbued with both salts darken more quickly than if the nitrate alone is present, and also because iodide of silver, precipitated from an excess of the nitrate in a test tube, will be found to change colour under the sun's action, while nitrate in such circumstances is not darkened except the light is assisted by organic matter. Some other reaction must consequently occur in this instance between the iodide and the nitrate in solution. It is found on trial, that whatever change takes place there is no liberation of iodine when iodide of silver and solution of nitrate are acted on by light, nor of any of the elements, except nitric acid, which remains in the solution; whatever change takes place is in their arrangement only, for in the dark the yellow colour is restored, except organic matter interfere to prevent: the yellow salt may be thus darkened, and restored many times in succession. A similar change occurs when a brown aqueous solution of iodine is exposed to light: no oxygen is given off, as has been already observed, yet very slowly the brown colour disappears, but is gradually reproduced in the dark. When the colourless solution is examined, it is found that the iodine, not being able to displace oxygen, has combined with both elements of the water in such a way as to form hydriodic acid with the hydrogen, and iodic acid with the oxygen: $5\ H\ O + 6\ I = I\ O_5 + 5\ H\ I$. These acids form colourless solutions. But in the ordinary course of chemistry, hydriodic acid is decomposed very quickly by iodic acid, water being formed and iodine set free. This sufficiently explains the reappearance in the dark of the brown colour which the light destroyed. When free iodine is added to a solution of nitrate of silver, if iodide of silver only were formed, then, besides nitric acid, an atom of oxygen would be liberated; for $Ag.\ O + N\ O_5 + I = Ag.\ I + N\ O_5 + O$; but here also, iodine not having the power of liberating oxygen, forms with it iodic acid, and so iodate of silver: $6\ Ag.\ O\ N\ O_5 + 6\ I = Ag.\ O\ I\ O_5 + 5\ Ag.\ I + 6\ N\ O_5$. The reason, therefore, why light has not sufficient power to decompose iodide of silver in the presence of water only, and yet can so decompose it when nitrate of silver is also present, is tolerably obvious. In addition to the tendency which iodide of silver has in the light to give up iodine to form hydriodic acid and iodic acid, another force is introduced viz., the attraction which the oxide of silver in the nitrate has for those two acids; and it is easy to suppose, that though either force separately might be insufficient, yet the two in union might be able to complete the change. The formula of the decomposition would be $6\ Ag.\ I + 6\ Ag.\ O\ N\ O_5 = Ag.\ O\ I\ O_5 + 5\ Ag.\ I + 6\ N\ O_5 + 6\ Ag.$, if we suppose the silver is reduced to the metallic state; or if we suppose it to become reduced to subiodide only, which seems more probable, the 6 atoms of metallic silver which are shown in the formula will be united to 6 atoms of undecomposed iodide. In the dark, if no organic matter prevent, this arrangement of the elements is altered and nitrate and iodide of silver reformed. When organic matter, such as paper, is present, the reaction will be different if an organic salt of silver take part in it instead of the nitrate. This organic matter may have such an affinity for the atom of oxygen, the non-liberation of which causes the above formulæ to be so complex as to cause an entirely different change, or it may by its affinity for the subiodide simply maintain the arrangement of the salts which light has induced. The former is probably its action in developed prints, the latter in sun prints. We cannot wonder if this be the correct view of the darkening of iodide of silver, that it should be carried to a much less degree than in the case of chloride, where not a fresh arrangement of the salts merely but actual release of one element occurs. The light is barely sufficient in the iodized paper to overcome the inclination which the salts have to return to their first condition, and this inclination increases as the iodate and the free nitric acid accumulate; the reduced subiodide is of a dingy colour, with very little force; and the quantity of nitrate of silver must be small, because strong nitrate of silver has the property of dissolving iodide to such an extent that, if allowed by evaporation to become concentrated, the whole surface of the paper would be whitened and its sensitiveness destroyed; and the organic matter has no influence directly on the iodide, any more than it has on the chloride. For these reasons the chloride is universally employed in sun-printing.

II. *Development-Printing.* — By development is meant the rendering visible an invisible actinically formed image, or the intensifying a visible one, by means of chemical reagents acting by their ordinary chemical affinities independent of the light. Both visible and invisible impressions of light may be developed. A body whose presence in a certain preparation is *essential* to its modification by light, is called a *sensitizer;* if *not essential* to the actinic influence taking effect, but only favouring the production of the effect in a shorter time, it is an *accelerator*; if itself decomposed in such a way by the substance which has already been modified or decomposed by light as to attach itself to it, or in any other way render the effect perceptible or plainer than before, it is a *developer*. The same compound may fill all three offices, but its use is different in the three cases. It is important to remember that the developer is always a compound, either decomposing spontaneously, or suffering decomposition by the substance produced by light in the sensitive surface. In the usual processes of photographic printing by development, the developer is always a mixture of solutions which are gradually letting fall a precipitate by their action on each other. The principle of development is therefore altogether different from sun-printing, and the chemistry proceeds on altogether a different principle. The power which is continually acting in sun-printing is the power of light in causing certain elements to unite: the force resorted to in development is simply the attraction of cohesion, by which atoms which are homogeneous tend to cling together. So entirely is this true, that after a print has been developed, washed, altered by a fixing solution, and washed again, after it has been dried and knocking about for months, the process of development may be continued. When the image has, therefore, once been formed in the camera, or the pressure frame, all that is done further is to pour over them a mixture from which silver, in some form, is being very slowly precipitated, so that at the moment when the precipitate is being liberated from the solution it finds itself in contact with the particle to which it has a tendency to adhere, just as when chloride of silver is being precipitated from the nitrate, the particles which are within each other's sphere of attraction, cohere to form a flocculent mass instead of going separately to the bottom. All that is necessary previous to development is, that centres of attraction shall be formed by the change which light has caused, having this affinity for the particles which are to be precipitated upon them. What are the particles which are thrown down by the usual developers? These developers are nitrate of silver mixed with either sulphate of iron, gallic acid, or pyrogallic acid.

When nitrate of silver and sulphate of iron are mixed in solution, the iron takes the oxygen of the silver and the silver is precipitated in the metallic state. When gallic or pyrogallic acid is used, the precipitated silver is found to be combined with a small quantity of organic matter, which has not been examined. The image differs therefore in the three cases, but until a proper analysis has been made, we cannot do more than point out the more truly metallic nature of the image formed when a protosalt of iron is employed, than when recourse is had to an organic deoxidizer.

Both chloride and iodide of silver have been extensively used for printing by development. The same objection does not lie against the iodide, in this mode of producing pictures, that was found in sun-printing. Though giving a very feeble direct print, it is found that the incipient image is more quickly formed, and the reason may be easily drawn from what has been already remarked. A rearrangement of the elements, and a production of suboxide sufficient to develope upon, is very speedily effected, and that long before any impression is perceptible to the eye, and when the developer is applied, having a strong affinity for oxygen, the atom of oxygen which prevented the formation of iodide without iodate is removed and the development proceeds rapidly. But in the case of chloride, the decomposition, because more complete, requires a stronger and more prolonged action of the light, and the image must be quite visible before the development commences.

Two effects are observed in printing by development on iodide of silver which do not occur on the chloride. These are such a reversal of the usual manner of impression by the light that, on development, the precipitating silver is adherent on the parts which have had the least intense light upon them, instead of those which have been most vividly illuminated; and the other is a reddening of the image in the parts which have been struck by the highest lights. They are probably, both of them, to be accounted for by changes produced in the sensitive surface, by light of a certain intensity and duration, in which the elements return to their unimpressed state, or some element is actually eliminated. The iodide of silver with the nitrate is subject, as has been shown in the paragraphs on sun-printing, to hover between two states, either of which it may be made to assume at pleasure. When acted upon by light, iodate, iodide, and subiodide of silver are formed, and nitric acid liberated. This liberation of nitric acid, against its affinity for oxide of silver, must have a retarding effect upon the gradual change operated by light. That the state of the substances after insolation is somewhat forced and strained when judged of by ordinary chemical affinities, is shown by the fact, that darkened iodide of silver, in the absence of organic matter, will return to the yellow form; and therefore, as the nitric acid increases in quantity and in power, with the intensity and duration of the illumination, a time is likely to arrive when it would suddenly upset the constrained relations of the parts, and reproduce the original arrangement. In this case, the most strongly lighted parts would receive little or no deposit in the development. This view of the matter is confirmed by the circumstance, that it is when a bath of nitrate of silver, containining much nitric acid is used, and when little or no organic matter is present that this reversal takes place. It has been produced and remedied many times successively, and with absolute uniformity, by alternately using a large comparative quantity of nitric acid, and of acetic acid, nor is it observed except when pictures of a leaden metallic appearance are being developed, the colour and feebleness of which are indicative of nitric acid and metallic silver, free from organic admixtures. It is also sometimes purposely produced by exposing the plate for an instant to the light at the very commencement of the development. This momentary exposure perhaps acts just as the intenser light in the more exposed parts of the image, to which we have adverted. If this explanation be correct, a true alternation ought to take place, in the effect, since when the particles are again placed in the *status quo ante* the further impact of light would operate as at first. Some experimenters have said that this regular alternation of effects really occurs. A similar phenomenon is observed when hydrochloric acid is subjected to electric sparks: the hydrogen and chlorine are separated until a certain point is reached, and then another spark causes their instant and explosive recombination. The effect seen in the reddening of the skies of landscapes and of the strongest lights in portraits may be the same thing, prevented by organic matter from fully taking effect, or more probably be only the consequence of more violent action upon the developer.

These observations show that if the use of iodide of silver be attended by the great advantage of sensitiveness, the sensitiveness is itself the cause of disadvantages which it requires skill to obviate. On chloride of silver the sun-printing and development may be mixed in any proportion, and to the experimenter's taste without entailing any of these inconveniences.

Space will not allow any detailed explanation here of the chemistry of the fancy photographic processes, or even of the numberless interesting photo-chemical experiments on particular salts which have been recorded; they are briefly noted in their own places. The principles above laid down are the main clue to the interpretation of all.

**CHIAR' OSCURO**; (Italian, "Chiaro," light, "oscuro" dark). The light and shade of a picture is called "chiar' oscuro," a term much used by artists. *See* "Breadth."

**CHINA CLAY.** *See* "Kaolin."

**CHLORACETIC ACID.** An acid formed by exposing acetic acid and chlorine to light. Chlorine displaces hydrogen, until $C_4 H_3 O_3$, $H O$, becomes $C_4 Cl._3 O_3$, $H O$.

**CHLORATE OF POTASSA.** $K O$, $Cl. O_5$. This salt is used in the production of oxygen gas, which it gives off readily when mixed with a small quantity of binoxide of manganese; its oxygen is the element which causes its use in the manufacture of lucifer matches, and of those compounds which are intended to burn with an intensely vivid light. It has been used as a first wash for paper, instead of a chloride.

**CHLORIDE.** The compounds of other elements with chlorine are either acids or chlorides. With oxygen and hydrogen it forms acids, with metals and other elements chlorides. The chlorides of the alkalis and alkaline earths are used in photography not as sensitive bodies, but as convenient salts for the production of those which are. The chlorides which would be especially likely to be affected by the light falling upon them, are the compounds of silver, platinum, and metals not easily oxidized; and also such metals as iron, which have several oxides and chlorides, and combine in more complex forms than those whose affinities for oxygen and chlorine are much stronger, and whose salts are much simpler. Iron, for instance, has four oxides and two chlorides, and the oxygen and chlorine appear to have the power of replacing each other in some cases. Their relations resemble those of organic compounds more nearly than those of many simpler inorganic bodies, and would therefore appear to promise the production of compounds suitable for the production of photographic images. Cobalt, copper, iron, and manganese are especially remarkable for these properties, and many have been already found to be decomposed, or modified, by light and organic bodies. Chlorine appears to have a greater affinity for most of the metals than oxygen, so that it is removed by heat and light with greater difficulty; and though chlorine at a high temperature decomposes most of the oxides, and entirely disengages the oxygen, oxygen acts only on a very few chlorides, principally of the class which has been spoken of as forming complex arrangements. Iron seems to be nearly balanced between chlorine and oxygen, for sesquioxide of iron dissolves in hydrochloric acid to form sesquichloride of iron and water; but the sesquichloride, evaporated and exposed to the action of the air, again forms sesquioxide and hydrochloric acid. There can scarcely be a doubt that this last action would be accelerated by light. Water is decomposed at ordinary temperatures by the perchlorides of manganese, chromium, columbium, and tungsten, and by the chloride of arsenic: hydrochloric acid and a metallic acid are the results. Chloride of tungsten is decomposed by it, with the disengagement of hydrochloric acid, and the precipitate of oxide of tungsten of a violet color. Water also acts upon the chlorides of antimony, bismuth, and tellurium, decomposing them into oxychlorides which are insoluble, and chlorides soluble in the atoms of hydrochloric acid formed. In the reaction of water upon the subchloride of tellurium some of the metal is even reduced to the metallic state. The chlorides of silver, platinum, gold, &c., are believed to be all decomposable by water and light, more or less easily. Some that do not appear to form hydrochloric acid with water, as the bichloride of mercury, do so in the light in ether, or other solvents. The alkaline and earthy chlorides, whose connecting affinity is stronger, do not appear to be oxidized or reduced by water, in which they are very soluble; but chloride of sodium and others will speedily give colour in the light to alcohol and other hydrogenous solvents. It is impossible not to see in all this that the affinity which is instrumental in causing these changes is that of hydrogen for chlorine, nor can the mind escape the impression that this is all extremely interesting as an illustration of the probable action of light in most of the instances in which its chemical effects have been observed. Many of these reactions of water and chlorides have been observed by chemists, without any attention to the share which light might take in the operation: but this is a subject highly worthy of investigation. As the chlorides are most of them used to form chloride of silver, their equivalents and solubility in water, or insolubility, should be attended to.

CHLORIDE OF AMMONIUM. $N H_4 Cl. = 54$. Applied as a first wash to printing papers, and in chloridizing collodion: 54 parts of it for these purposes are equal to 60 of chloride of sodium, and to 105 of anhydrous, or 123 of crystallized chloride of barium: it dissolves sparingly in alcohol; about 1·5 per cent. in alcohol S. G. 834, or 6 grains to the fl. oz. The nitrate of ammonia formed is a solvent of oxide of silver, and therefore sometimes injurious: when papers or plates are placed successively in the same silver bath it accumulates. It dissolves bromide and chloride, but not iodide, of silver: and gives a picture less red than chloride of sodium produces.

CHLORIDE OF BARIUM. $Ba. Cl. = 105$, or $Ba. Cl. 2 H O = 123$. The crystals are much less soluble in alcohol than those of the last-named salt, spirit of S. G. 834 dissolving only $\frac{1}{600}$ per cent. It gives a slightly more purple colour to the reduced subchloride than either the salt of ammonium or sodium: mixed with chloride of gold, it gives a surface sensitive to light and affects the tint of the reduced metal. It is used as a test for sulphuric acid, and for carbonate, iodate, and sulphate of potass, existing as impurities in iodide of potassium: it is precipitated as a white salt when these impurities are present. It is much more soluble than nitrate of baryta.

CHLORIDE OF BROMINE. The mixture of chlorine and bromine, so-called, used as an accelerator in the daguerreotype, is not a definite compound.

CHLORIDE OF CALCIUM. $Ca. Cl. = 56$, and, when hydrated, $Ca. Cl., 2 H O = 74$. This salt is soluble in almost any quantity in water at 220°: its attraction for water being so great, that it soon deliquesces in the air, becoming what was once called oil of lime. On this account it is employed freshly fused to deprive gases of aqueous vapour, and as a means of depriving ether and alcohol of water. It is copiously soluble in alcohol: ten parts of anhydrous alcohol S. G. 794 dissolve seven of the chloride, and the solution in cold weather affords crystals containing 60 per cent. of alcohol, instead of water of crystallization. It may be conveniently used in testing comparatively two samples of collodion for water, by dissolving 6 or 8 grains, while hot after fusing, in a drachm of the plain, or in half a drachm of iodized collodion. As often sold it is in the form of the hydrate, and, when warm, dissolves in its contained water: this must be boiled away, and the dry salt then fused. When employed on printing paper it gives a very red picture: the nitrate of lime formed is deliquescent, and may prove injurious if the paper be long kept. Newly-made anhydrous chloride of calcium is phosphorescent. It is often present in common salt, and then makes it very moist. It must not be confounded with chloride of lime, which contains oxygen as well as chlorine.

**Chloride of Copper.** There are two chlorides of copper, a subchloride $Cu._2$ Cl. and a chloride Cu. Cl.; the latter is the salt generally employed. When copper wire is twisted into a spiral form, made hot, and plunged into a vessel of chlorine, it burns like iron in oxygen, though with less intensity: thick vapours of the chloride are formed, which are every now and then rifted by sparks of vivid flame. It parts readily with half its chlorine, and has been on this account added to hyposulphite of soda to produce toning properties, which it does in the same manner as free iodine; also to assist iodide of potassium in bleaching papers which have been prepared with the sensitive silver salts and darkened by the sun; and in giving chlorine to silver plates immersed in its solution, with a view to form a coating of violet subchloride of silver that shall give the colours of the spectrum.

**Chloride of Gold.** There are two chlorides of gold, viz., Au. Cl. and Au. $Cl._3$: the former is prepared by heating the latter to the temperature of melting tin, till no more chlorine is evolved, and is decomposed by water into the latter and metallic gold. The second of these two only is soluble, and is the salt generally called the chloride of gold. Gold unites directly with chlorine, and it also dissolves in an aqueous solution of chlorine. Gold cannot decompose hydrochloric acid, either dry or in solution, because the attraction of chlorine for hydrogen is greater than for gold. It can liberate the hydrogen in neither case: but if nitric acid be also present in the solution, then the hydrogen, instead of escaping, forms water with the oxygen of the nitric acid and disengages $N O_2$, which is held by a much more feeble force than the hydrogen of either hydrochloric acid or water. The attraction of chlorine for gold is stronger than that of $N O_2$ for $O_3$. But the affinity of chlorine for gold is not great, and hence it is easily driven off by heat. It is also reduced to the metallic state by protosulphate of iron, and by gallic, acetic, citric, oxalic, and other acids which take oxygen, and then forms hydrochloric acid from the elements of water. When neutral, the compound and its solution are red; but if hydrochloric acid be present, yellow. It is of important use in photography: in the art it is constantly made use of for toning the red newly-fixed images, for making the sel d'or, or double hyposulphite of gold and soda, for gilding daguerreotypes, and *even* in chloridizing collodion, and, mixed with other chlorides, in preparing papers for the printing frame. It has been further applied to the reduction in strength of over-printed positives, and to the restoration of those which have faded. Solution of chlorine, or any easily decomposed chloride, as the perchloride of copper, or bichloride of mercury, will reduce a print, when quite bronzed, to a reasonable condition as well as the chloride of gold. To revive a print, immerse it in a bath composed of 40 grains of the chloride to a pint of water rendered slightly acid with hydrochloric acid: in the light of the sun a few minutes are sufficient, but in the dark three or four hours are necessary to complete the restoration, when the print must be fixed again with fresh hyposulphite. The other uses are explained elsewhere. It is best kept in solution. To make it, place a half-sovereign in a vessel containing nitro-hydrochloric acid and digest with a gentle heat: add fresh aqua regia when action has ceased if it be not entirely dissolved. The solution will contain chloride of gold and chloride of copper, and free acid: add, therefore, carbonate of soda enough to neutralize the acid and precipitate a green salt of copper, which may be left till the next day to settle. The solution will contain about 85 grains of chloride of gold, and if rendered slightly acid, and made up to 85 fl. drachms, will be stable, and each drachm will represent a grain of the chloride.

Chloride of gold is a photo-sensitive salt: a piece of paper moistened with it and exposed to light becomes purple in consequence of its decomposition. The oxides of gold are more or less purple, and the finely divided metallic gold reddish brown: the chloride of gold would, therefore, appear to be reduced to an oxide, $Au.\ Cl._3, + 3\ H\ O = Au.\ O + 3\ H\ Cl.$ This oxide has not the instability of the teroxide in the light. Pictures toned with gold in the form of teroxide have been known to become redder in time owing to the reduction of the gold to the state of pure metal. The terchloride of gold is the basis of the *chrysotype* process, but it is merely a developer in this case. A persalt of iron in the pores of the paper is reduced, by light, to the state of protosalt in the sunned portions, and upon this, by the reducing power of the iron itself, gold is precipitated in the metallic state, or silver if nitrate of silver be brushed over the paper instead of terchloride. If chloride of gold and chloride of barium are both in the paper when the exposure takes place, then instead of the gold appearing in the purple colour of the oxide, the first effect is to remove the slight pinkey or yellowish colour of the gold salt entirely and then slowly and feebly darken it. But before any decidedly visible image is formed if the paper be immersed in water, the picture is rapidly developed to a full purple brown. Hot steam has the same effect as water and is more energetic. The following is probably the rationale of this interesting change which has not hitherto been explained. Chloride of gold ($Au. Cl._3$), forms with chloride of barium, ammonium, &c., double salts containing an atom of each, and which crystallize in a regular manner with four or five atoms of water. The gold cannot be precipitated by alkalis from the solutions of these salts : and in this and their constitution they resemble the double salts of citrate of iron and citrate of ammonia and the like, such as the potassio-tartrate of iron, the ammonio-oxalate of iron and many others. When these double salts of iron are exposed to light the oxygen and carbon of the organic acid are so excited—*See* " Chemistry of Photography,"—that carbonic acid is formed and escapes, and as a consequence the salt is reduced to the state of protoxide. Similarly when the double chloride of gold and barium is solarized, hydrochloric acid escapes and the gold is reduced to the state of protochloride. But protochloride of gold, though permanent when dry, is quickly resolved by water, and especially by hot water into metallic gold and perchloride. The first *whitening* effect observed is the formation of the protocloride and the subsequent darkening is the commencement of the resolution of the double compound by the action of the atmosphere. Similar effects occur with oxalate of ammonia, acetate of lead, bichromate of potash and iodide of of potassium with this chloride.

Chloride of gold can be *entirely* separated in the neutral state from the acid solution by means of ether, which dissolves it more readily than water. The hydrochloric acid remains with the water. This is a neat way of neutralizing it for the preparation of toning baths. The salt is extremely deliquescent, and, therefore, cannot be conveniently kept *dry*: its solution in pure water, slightly acid, will not decompose, but an alcoholic or ethereal solution might decompose in the light, if kept long.

CHLORIDE OF IRON. What is usually called the chloride of iron is the sesquichloride or perchloride ($Fe._2\ Cl._3$), it is formed by dissolving the peroxide ($Fe._2\ O_3$), in hydrochloric acid and evaporating to dryness. It is soluble in alcohol and ether, and deliquescent. The alcoholic solution is the *tincture* of the shops; boiling alcohol dissolves its own weight. Added to hyposulphite of soda it produces sulphur compounds which impart good tones to photographs, but make them liable to fade: it acts on the soda compounds as free chlorine would, and loses chlorine. Mixed with iodide of potassium and spread over darkened chloride paper, it bleaches out the dark impression in the light, the potassium giving iodine, and the iron chlorine, which combine with the reduced silver.

CHLORIDE OF LEAD. A white fusible compound crystallizing in needles from hot solutions, and in some respects resembling chloride of silver. It is insoluble in alcohol, but very soluble in hyposulphite of soda, in combination with which it makes a good toning bath for positives. Chloride of lead is obtained by digesting litharge in hot hydrochloric acid.

CHLORIDE OF LIME. Bleaching powder, soluble in ten parts of water and then called bleaching liquor. Formed by exposing hydrate of lime to the vapours of chlorine. Similar compounds are produced by substituting bromine or iodine for chlorine, and they constitute the best form of accelerator for imparting bromine to the iodized daguerreotype plate. They contain calcium, oxygen, and chlorine or bromine, and are now generally supposed to be hypochlorites, &c. Chloride of lime is thus represented as $Ca.\ Cl. + Ca.\ O.\ Cl.\ O.$ The greatest attention must be paid in forming these salts to keep down the temperature, or entirely different and useless compounds will be produced; these even form at common temperatures in the course of time. The carbonic acid of the air is quite strong enough to decompose them and evolve the hypochlorous acid, &c., which has powerful bleaching properties. Chloride of calcium contains no oxygen: the lime salt is sometimes not entirely removed from paper after bleaching,

CHLORIDE OF MAGNESIUM. $Mg.\ Cl.$ This salt is of great use in the collodion process, when it is thought desirable to add a chloride as well as an iodide to the iodizing solution, for it is soluble in twice its weight of alcohol. Its effect is to increase the density of negatives, and prevent solarization of the skies; it is also useful in the dry process, for increasing the sensitiveness of the plates by rendering the perfect removal of the free nitrate of silver unnecessary. In printing transparent collodion positives upon glass, it increases the density and vigour of the blacks, and improves the tone of the picture. The nitrate of magnesia formed in the N.S. bath is an acid salt, with an effect resembling that of free nitric acid.

Chloride of magnesium is extremely deliquescent. It is obtained by passing hydrochloric acid over red-hot magnesia. Sea-water contains about one-fifth part as much of it as of chloride of sodium.

**Chloride of Mercury.** Hg. Cl. Calomel. When 100 is taken as the atomic weight of mercury, this salt is a subchloride or dichloride, since it takes two equivalents of 100 each to form with one equivalent of chlorine (36), one equivalent of the chloride 236; but when 200 is taken as the atomic number of mercury, then this salt is called the chloride. The opinion of chemists in general is, that 100 should be taken as the equivalent number of mercury, and, if so, calomel will be a subchloride, though in commerce it is still called the chloride, and corrosive sublimate the bichloride. Calomel is insoluble; like the subchloride of silver it is resolved by solvents (hydrochloric acid) into metal and a higher chloride: it phosphoresces when scratched. It is decomposed by alkali, and ammonia, and black suboxide is one of the results. This black suboxide is what is formed when photographs are whitened by bichloride of mercury, and the produced chloride of silver and chloride of mercury are acted upon by ammonia. The bichloride of mercury is soluble in 18 parts of water at 60°, and in 3 of hot water, in 2 parts of alcohol and in 3 of ether, also in its own weight of hydrochloric acid. By *parts*, are intended parts by weight. *See* "Bichloride of Mercury."

**Chloride of Nickel.** Formed by dissolving nickel or its oxide in hydrochloric acid, and heating the salt to redness. Soluble in hot water.

**Chloride of Platinum.** The chloride of platinum usually spoken of is a bichloride ($Pt.\ Cl._2$) easily soluble in water, ether, or alcohol. The protochloride (Pt. Cl.) is insoluble like the corresponding salt of gold. When the bichloride of platinum is mixed with lime water, or solution of carbonate of soda, and exposed to light, a white precipitate is caused in the lime water, and a red precipitate in the soda solution. The white powder has been determined by Weiss and Döbereiner to be a hydrated compound of chloride of calcium with lime and peroxide of platinum, having the formula $Ca.\ Cl. + Ca.\ O,\ 2\ Pt.\ O_2 + 7\ H\ O$; and the red crystalline precipitate to be $Na.\ O,\ 3\ Pt.\ O_2,\ 6\ H\ O$. These two compounds are sufficiently complex and might seem to indicate a very intricate reaction when the solar rays fall upon the mixture. It will be found, however, on examination that the increase of attraction of chlorine for hydrogen in the light will account for the change in a very simple manner, thus :—

$$2\ Ca.\ O + 2\ Pt.\ Cl._2 + 10\ H\ O = Ca.\ Cl.,\ Ca.\ O,\ 2\ Pt.\ O_2, + 7\ H\ O + 3\ H\ Cl.$$

and

$$Na.\ O\ C\ O_2 + 3\ Pt.\ Cl._2 + 12\ H\ O = Na.\ O,\ 3\ Pt.\ O_2, + 6\ H\ O + 6\ H\ Cl. + C\ O_2,$$

from which formulæ it will be seen that in both cases hydrochloric acid is formed, and that the platinum becomes oxide instead of chloride. The light does not appear to have the power of causing water alone to decompose chloride of platinum as it does chloride of silver, but when other substances are present which have an affinity for oxide of platinum, and, therefore, may be supposed to exert some force in its formation, then the decomposition by light will take place. Paper has the power of slightly decomposing chloride of platinum in the light, for with some days' exposure, the effect is visible. In one of Sir John Herschel's experiments neutral bichloride of platinum was exposed to the sun and brushed over afterwards in the dark with nitrate of silver. The picture was weeks before it began to develope, but still it developed in all its details. It has been used as a toning agent both before fixing and also in the toning bath, just as chloride of gold, but it is not so energetic, and the tone is less pleasing.

**Chloride of Potassium**, $K\ Cl. = 76$. This dissolves in 3 parts of water at 60°, but is insoluble in alcohol. This salt is a residue in several chemical processes and is often present as an impurity in the iodides and bromides of the metals, and in nitre as occurring in commerce. In preparing papers it is not much used, though the nitrate of potassa formed in sensitizing would not be so likely to damp the paper and spoil it when kept, as nitrate of soda.

**Chloride of Silver**, $Ag.\ Cl. = 144$. Formed by precipitation when a soluble chloride is added to nitrate of silver or other soluble salt of silver, and of essential service in photography. It is perfectly insoluble in water, ether, and alcohol; but soluble in alkaline chlorides, hyposulphites, cyanides, bromides, iodides, &c., and in ammonia. When dissolved in a chloride or other such salt, double salts are formed soluble in a small quantity of water, but not in a larger; hence adding water to a clear solution decomposes them, throwing down the silver salt. Hyposulphite of silver is often thus seen in the interior of papers, where dilute solutions of hyposulphite of soda have been used in fixing photographs. And in consequence of this law of solubility the more concentrated the alkaline solution, the more silver salt will it dissolve. When chloride of silver is dissolved in this manner, it is no longer chloride, but hyposulphite, cyanide, or as the case may be, the chlorine going to the alkali. It is also soluble to a minute extent in nitrate of silver, and thrown down in a similar manner by water in excess. It differs from iodide of silver in being more soluble in haloid salts, but less so in nitrate of silver; iodide of silver is not soluble at all in ammonia. At 500° of temperature it fuses and concretes into a substance grey and semi-transparent resembling horn. It is reduced to the metallic state by fusion at a bright red heat, with twice its weight of potassa, or soda, or carbonate of either; also by boiling with potassa in solution, especially when sugar is also present; and by zinc, tin, lead, iron, copper, mercury, and some other metals when moist, and more quickly when hydrochloric or sulphuric acid aids the decomposition by its conducting power, for the force in these cases is that of electrolysis. Zinc filings triturated with moist chloride of silver decompose it with such heat, that the zinc and metallic silver fuse together.

Chloride of silver is said by some to be decomposed by light without the intervention of other elements: but this view is not at present supported by sufficient evidence. When decomposed by sunlight in the presence of water, chlorine has been spoken of as existing free in the water, and if this be correct then it is a proof that the water was not the cause of the decomposition, but if it exists in the water in the form of hydrochloric acid and not chlorine, then it is a proof that water took part in the change. That hydrochloric acid is formed and oxygen liberated cannot be denied, but it is said some chlorine is also found in the free state, but no satisfactory proof of this has been produced. Chloride of silver has been decomposed by light in an atmosphere of chlorine, but in that case the experiment was tried on the salt as formed in the pores of paper which contains hydrogen. Niépce found it to be discoloured in vacuo when bitumen and other organic matters which in the air are decomposed by light remained intact, but a perfect vacuum is not attainable, and chloride of silver is much more sensitive than bitumen. When presented to light under sulphuric acid in a stopped bottle, quite full, no change takes place; and that the acid, as such, does not prevent its discolouration is proved by the fact, that the change goes on if the stopper of the bottle be removed so that air can reach the surface of the acid. If air, or moisture rather, can act on the chloride through the sulphuric acid we may well suppose it can in an imperfect vacuum. Chloride of silver will thus be reduced by light even under strong nitric acid. It has been given as a proof that it is directly decomposed, that it blackens when carefully freed from moisture and exposed under benzole in a tube from which the air is expelled by boiling the benzole. But benzole contains hydrogen, and is very much inclined to unite with chlorine: this only shows that if the benzole were pure the chloride can be decomposed without being oxidized: and that it is not oxidized in these experiments is also shown by the accumulation of oxygen, above the water, in the bottles in which they are conducted. Pure isolated chloride of silver appears therefore to be not decomposable by light: and the presence of hydrogen, or a body having affinity for chlorine, seems essential to its decomposition. The part of the spectrum which acts on chloride of silver includes the rays from the green towards the violet, to a space quite beyond the visible spectrum: the portion from the green to the extremity of the red, collected to a focus so bright that the eye can scarcely endure it will not discolour chloride of silver exposed to it for hours. The point of maximun effect is even beyond the violet end. From the power which it possesses of displacing and setting free oxygen from hydrogen it suffers a loss of chlorine in the light, but there is no corresponding liberation of iodine and bromine from their silver salts in consequence of their having weaker affinities than oxygen: hence the chloride gives the stronger image in the light. But the actual liberration of the oxygen requires a stronger and more prolonged action of light on the part of the chlorine than is necessary to change the iodide and bromide, for these change colour and darken slightly though they lose no iodine or chlorine, and set free no oxygen. They enter into new combinations, merely, and hence are more quickly altered than the chloride, and give a picture, by development, with less insolation.

Though a picture is produced by light on chloride of silver, no chloride remains in the fixed image, and therefore the same result can be obtained by using other silver salts: it is only useful as accelerating the action. An image formed, directly, on pure chloride of silver with excess of nitrate on a glass is, after fixing, metallic silver: if developed with a protosalt of iron, it is the same: if developed by pyro-gallic or gallic acid it contains elements of the decomposed organic acid. On paper the image is always combined with organic matter: on collodion it is often nearly pure metallic silver. The chloride will not give strong pictures without excess of nitrate, and when, in following the usual method of proceeding, the picture comes out mottled with white or feeble patches, the silver bath has become too weak, or not enough was brushed on, or the paper did not float on it long enough, or the cold weather required the paper to lie on the silver longer than usual.

Chlorine is a much more powerful element in its affinities for organic compounds of hydrogen, carbon and oxygen, than iodine: it decomposes them by displacing hydrogen and intruding itself into the gap. Iodine is much less intrusive in this way. Hence in sun-prints, and prints by development, the presence of organic matter has a much more powerful influence on the resulting picture, its appearance, and its composition, when chlorides are present than when iodides alone are used. The action of the chlorine in displacing hydrogen is attended with the formation of bodies of acid properties which unite with the reduced metal. Pictures produced on iodide of silver, are, therefore, more metallic in their composition than those on chloride, and bluer and colder in their appearance. The finished pictures vary also, as might be expected, in their susceptibility of change, by oxidizing, or sulphuretting, or other compounds: the purer metal is generally more permanent, and developed prints more stable, than sun-prints. A russet apple keeps better that a rosy-cheeked one.

**Chloride of Soda.** A compound like chloride of lime. If this be used instead of chloride of sodium in preparing papers, chlorate of silver will be formed as well as chloride, and the sensitiveness decreased.

**Chloride of Sodium.** Na. Cl.=60. Common salt. A thousand parts of common salt contain from 930 to 990 parts of pure chloride of sodium: chloride and sulphate of magnesia are the impurities. If wanted pure for analysis or for testing silver baths, it must be made by exactly saturating pure hydrochloric acid with carbonate of soda, so as to make a perfectly neutral solution: but rock salt is quite pure enough for printing, and other such purposes: if it contains much magnesia it deliquesces. There is a peculiarity in the solubility of salt, viz. that it is as soluble in cold water as in hot: it requires three parts of water to one of salt. Half an ounce only is taken up by 100 ounces by weight, of alcohol, of S. G. 834. so that a very small quantity only could remain in solution in collodion, since it is still less soluble in ether and that part would be liable to precipitation in the setting of the film.

CHLORIDE OF STRONTIUM. Sr. Cl. = 80. Obtained by dissolving carbonate of strontia in hydrochloric acid diluted, evaporating to dryness, and fusing the residue. If dissolved and crystallized, the crystals contain six atoms of water, and the equivalent will be 134. This salt is readily soluble in alcohol and in twice its weight of water: the crystals deliquesce.

CHLORIDE OF TIN. The protochloride of tin, Sn. Cl. is sold in commerce under the name of salt of tin: it strongly attracts oxygen, and, therefore, reduces many metallic solutions: on this account it has been recommended as an accelerator. It is partly decomposed by a large quantity of water, with the deposition of an oxychloride and the formation of free hydrochloric acid: unless this acid is present it quickly becomes turbid: the acid solution is a powerful deoxidizer. Chloride of tin is extensively used as a mordant in dyeing.

CHLORIDE OF ZINC. Zn. Cl. = 68, or, as produced by evaporating its solution, Zn. Cl. H O = 77. It may be formed by evaporating a solution of zinc in hydrochloric acid to dryness, and heating the residue red-hot in a glass tube with a small aperture. The solution of this salt is always acid, and cannot be neutralized till all the zinc is precipitated. Zinc has a very powerful affinity for chlorine. Its acidity is not in favour of its use photographically: it is soluble in its own weight of alcohol.

CHLORINE (χλωρος, green). Chlorine is so called from its colour: it is a greenish yellow gas. It is the most powerful electro-negative element, generally displacing oxygen. There are some who still think it to be an oxygen compound, and, if so, bromine and iodine also. These bodies all seem to be powerfully modified by solar light, and resemble each other in their chemical properties, but they are not all generally considered to contain oxygen. To obtain chlorine, a mixture of one part by weight of coarsely powdered black oxide of manganese, and two parts of common hydrochloric acid may be heated over a lamp in a glass retort: the evolved chlorine may be collected over warm water, as cold water absorbs it. The qualities which distinguish chlorine in chemistry are its strong affinity for hydrogen and the metals, and its bleaching power: in photography, the increase of its usual affinities by the action of light. Its bleaching power is a consequence of its affinity for hydrogen, since, on coming in contact with colouring matter in the presence of moisture, it decomposes the water, especially in the light, and the nascent oxygen unites with the colouring matter to form a new and colourless compound. In the same way it destroys organic substances in the atmosphere, carrying with them infectious disorders, and is, therefore, used as a disinfectant: hydrogenous gases and miasmata are thus destroyed, as well as vegetable and animal dyes containing hydrogen, and even the colour of ink, which is formed by gallic acid, of which hydrogen is a component. Engravings which are produced with printers' ink, a mixture of charcoal, vegetable dyes, and organic oils and resins, are not proof against the action of chlorine: even the carbon in such combinations may, by the joint action of light and this gas, be carried away as chloro-carbonic acid. Photographs are particularly liable to be thus attacked. Many substances are decomposed by chlorine with such violence as to cause combustion. Many organic substances appear to be capable of forming with chlorine as many different compounds as they contain atoms of hydrogen, the hydrogen being displaced by chlorine by single atoms at a time, which go off as hydrochloric acid.

As has been said, the affinity of chlorine for hydrogen and carbon is much exalted by the sun's rays, and organic bodies, unaffected by chlorine in the dark, are often rapidly altered by it in the light, and sometimes the alteration takes place with explosive violence. The nature of the effect produced on chlorine by light has not yet been determined: some suppose that it is rendered permanently allotropic; others, that an effect is produced upon it similar to the induction of electricity on insulated conductors in the proximity of an electrified body, which state or effect immediately ceases on the withdrawal of the exciting force. But the investigations of more than one experimenter seem to prove, that an effect is produced upon chlorine in the light which does not terminate with the exposure to light, but continues in the dark, and the darkening which occurs in iodide of silver, exposed with nitrate to the sun, is only gradually removed when it is afterwards taken into a dark place. It has been said by some that the light combines with the element to form a definite compound, but this is not consistent with what is now generally admitted as to the nature of the phenomena of light, and is not accordant with the undulatory theory which is now considered by most philosophers to be established. The action on the elementary body is probably an induced polarity of some kind, which continues for a longer or shorter period, even after the disappearance of the exciting force.

Chlorine is the only body capable of dissolving gold and platinum, and is a more powerful body even than oxygen. It constitutes with oxygen, bromine, iodine, and fluorine, a natural group of very similar bodies, of which it is the most energetic. In testing for chlorine in the free state, it is necessary to distinguish it from ozonized oxygen, which, being more active than ordinary oxygen, might, in some of its reactions, be mistaken for it.

At the temperature of 60° water dissolves twice its volume of chlorine, and more as the water is cooled: in this respect it resembles the binoxide of hydrogen, which gives off at high temperatures the oxygen which it holds in solution. Chlorine water acts like chlorine itself, but is decomposed by sunshine, with the formation of hydrochloric acid and liberation of oxygen.

CHLORO-BROMIDES, &c. These and similar compounds are often mere mixtures of chlorine and bromine, or iodine, in combination with water or lime, and used as accelerators in the preparation of daguerreotype plates.

CHLOROFORM. A compound of chlorine and formyle. Formyle is a hypothetical hydrocarbon, $C_2 H$; and chloroform is the terchloride of it, $C_2 H Cl_3$. It is a heavy limpid fluid of S. G. 1·48, insoluble in water, but soluble in ether and alcohol, from which it is thrown down by water. It dissolves camphor, wax, resins, gutta percha, and caoutchouc. Solution of gutta percha in it has been used as a film on glass to receive collodion, intended to be removed after the picture is taken, and also as a means of removing the film after the operations are all finished. It is successfully applied in both these ways to support the collodion instead of glass when used to print from, and has also been recommended as a varnish to protect photographic images in general. Added to collodion, it has been found sometimes to render it more fluid, tough, and contractile, and to remedy in part the want of half-tone often produced by old or impure ether; but it must be pure when used for these purposes, or it will be worse than nothing. It increases the density of the image slightly, but is not an accelerator. It is made by distilling a mixture of one pound of chloride of lime, three of water, and three ounces of alcohol. About three ounces of chloroform pass over.

Chlorophyl. (χλωρος green, and φυλλον a leaf.) The green colouring matter of leaves, which is not produced in the absence of light, and is produced by decompositions in which oxygen is liberated. When the green matter is oxidized by the action of chlorine or other bodies it is deprived of its colour. This action on living plants is the opposite of the effect of light on decaying matter, which is oxidized and gives off carbonic acid.

Chromate of Copper. $Cu. O Cr. O_3$. This salt is the buff precipitate which falls when solutions of chromate of potassa and sulphate of copper are mixed: it is sparingly soluble in water, and neutral. When bichromate of potassa is used, no precipitate occurs, the bichromate of copper formed being soluble. When a strong mineral acid is added to the sparingly soluble chromate in water, half the copper is removed, and forms a neutral salt with part of the acid, and the residue, as bichromate of copper, dissolves in the remaining acid water. This mineral acid may be neutralized; but, if alkali be added more than is necessary for this, then the bichromate is decomposed, and neutral chromate is again thrown down. The solution of bichromate, prepared in either way, and spread upon paper, is decomposed by light. As the neutral chromate is not found to be affected in the same way, or, at least, in the same degree, it is possible that the second atom of chromic acid is alone changed: *see* "Chromic acid." If the neutral chromate itself were decomposed, then some chromic acid would be deoxidized, and a dichromate of copper formed, and perhaps a chromate of chromium. The bichromate of copper has been tried as a means of procuring photographs on glass, which, when burnt in a glass furnace, should give a permanent image in coloured glass: the colour to be given by the oxides of copper and chromium.

Chromate of Iron. Chromate of the protoxide of iron cannot exist, since the iron abstracts oxygen from the chromic acid, and both become sesquioxides. The chromate of the sesquioxide of iron is soluble, like the corresponding chromate of sesquioxide of chromium: the formula is $Fe._2 O_3, Cr. O_3$. This compound has also been proved to be decomposed by light and organic matter, and two atoms of the chromic acid must be resolved into $Cr._2 O_3$ and $O_3$, and a subchromate produced. It is not impossible that the oxide of iron is at the same time reduced to protoxide, which will unite with the $Cr_2 O_3$, as a base with an acid. The sesquioxides of both iron and chromium are very feeble bases, and with strong bases even act as acids: the latter is the more stable and more acid compound.

Chromate of Mercury. 4 Hg. O, 3 Cr. $O_3$. This is a basic chromate, and becomes still more basic when exposed to the sun's rays: metallic mercury is at length formed.

Chromate of Nickel. A reddish-brown powder and neutral is the chromate of protoxide of nickel: the acid chromate is soluble. It resembles the chromate of copper.

Chromate of Potassa. K O Cr. $O_3$. This is the salt from which the other chromates are all prepared. It is soluble in twice its weight of water, but not in alcohol. *See* "Bichromate of Potass."

Chromate of Silver. Ag. O, Cr. $O_3$, is precipitated of a crimson colour, when chromate of potassa is added to nitrate of silver. It is also formed more gradually by the slow decomposition of bichromate of silver: the decomposition of one-half of the acid is effected by boiling, or by exposure to air and light: the neutral chromate forms then in dark green crystals. The sesquioxide formed remain in solution with the bichromates. Chromate of silver is decomposed by light and organic matter, with the production of metallic silver and oxide of chromium, and the organic matter is oxidized.

Chromatic Aberration. *See* "Aberration."

Chromic Acid and Chromates. Chromic acid is a teroxide of chromium Cr. $O_3$: and resembles ferric acid Fe. $O_3$. The compounds of iron and chromium are, indeed, generally so similar in their reactions, that we might almost expect them to act, photographically, in the same manner. Chromic acid is more stable than ferric, and peroxide of chromium than peroxide of iron: chromium, therefore, appears to have the stronger affinity for oxygen. Ferric acid is much more easily decomposed than chromic, though it is very difficult to keep either in the free state: the former, indeed, cannot be isolated, for it splits up into $Fe._2\ O_3$ and O. It is only in combination with very strong bases, such as potassa, that it can exist. Chromic acid, on the other hand, will form salts with a great number of bases, and, even, with such a weak base as $Cr._2\ O_3$: but these salts are more easily decomposed in proportion to the weakness of the base: the acid then, like the ferric, splits up into sesquioxide and oxygen. The strong bases generally will combine with either one or two equivalents of chromic acid, but the second equivalent is extremely liable to undergo the same change as free acid. Chromic acid is decomposed instantly by the contact of organic matter, which takes the oxygen, and it may be, therefore, employed as a bleaching agent, and, as this change is favoured by light, it may be used in a great variety of ways photographically: the principle of the operations being the exaltation by light of the affinity of oxygen for carbon. Oxygen and carbon are thus affected in a degree only second to chlorine and hydrogen. Alcohol is sufficiently active to decompose chromic acid: it is itself oxydized into aldhehyde and formic acid, which forms formic ether. This unstable body will not even allow itself to be filtered through paper without reduction.

There is a strong analogy between the photographic processes by means of the salts of chromium, iron, uranium, and aluminium, and the operations of dyeing. These salts are in both cases decomposed by the organic matter to be printed on, and the reduced oxide, which combines with the oxidized organic fabric, becomes a basis on which other oxides will subsequently adhere. The dyer, even, becomes at times altogether a photographer, when he makes use of the sun to impart greater brilliancy to his colours than their unaided affinities would produce. And the photographer becomes a dyer, when, having reduced his oxides on his paper by the light, he proceeds to deposit on them, as a mordant, other oxides by means of nitrate of silver, chloride of gold, ferrocyanide of potassium, and other substances used as developers. The colour of the dye is also often developed in a way precisely analogous. The mordant oxide appears to be such a one as can play the part of both base and acid, and hold out a hand both to the organic matter on the one side and the metallic oxide on the other.

It is often difficult to point out the exact formula which takes place when the salts of chromium and iron are reduced photographically and afterwards developed. When bichromate of copper, for instance, is decomposed, the reaction would be easy to understand if the sesquioxide formed were immediately precipitated in the solid state. But this oxide appears to form with the elements of the undecomposed compound complex double salts. The sesquioxides of iron, chromium, aluminum, manganese, are isomorphic, and form aluminoid salts with sulphuric acid and potassa of a complex kind: and such aluminoid double salts, with some slight modifications, appear to be formed in the decomposition of the bichromates. Chromic acid salts are isomorphous with the sulphates, and double chromates and chromosulphates are easily formed. When a neutral chromate is deoxidized, the decomposition is, probably, first into subchromate, sesquioxide of chromium, and oxygen, and, perhaps, afterwards, entirely into sesquioxide and protoxide;

but, when a bichromatic solution is used, these double aluminoid compounds are probably first formed. The first effect of light upon them is to deepen the colour, because of the formation of sesquioxide; but further action often bleaches this colour, and this, most likely, indicates the formation of a double salt, or of a salt composed of sesquioxide as the acid in the place of chromic acid. The action upon a developer is in both cases the same in kind, and depends upon the developer used: with nitrate of silver, chromate of silver appears to be formed in the parts NOT changed by light, and containing the original chromate, and with ferrocyanide of potassium compounds resembling Prussian blue, but containing chromium, in place of iron, as the base. Chromic acid will destroy a photograph more quickly than nitric.

CHROMIUM. A metal found in nature in the form of sesquioxide, united, as the acid, to the protoxide of iron, as the base: (χρωμα, colour). It is remarkable for forming coloured compounds, and hence its name.

CHROMATYPE. A name given to that class of photogenic decompositions in which chromic acid is deoxidized: the sesquioxide of chromium does not appear to undergo reduction to the state of protoxide, and in this it differs from the persalts of iron in ferrotype. The following are the modes adopted for getting photographs by the chromium salts:—

(*a*) Soak the paper in a saturated solution of bichromate of potash, and dry it by rapid agitation in front of a brisk fire out of the light. It is now of a bright yellow colour, but exposure to the sun under a negative, will produce a positive, by darkening the exposed parts to a deep orange colour. Washing well in water removes the unchanged yellow salt from the lights, but the reduced sesquioxide in the shadows remains combined with the paper. The paper should be well sized, or the bichromate will be only feebly decomposed.

(*b*) Brush a sizing of starch very uniformly over the paper, and then steep it in a weak alcoholic solution of iodine, and if the coating of blue iodide of starch be not uniform repeat the operation. Steep it in bichromate and dry it as before. The print will be negative, even, from a negative, and positive from a positive, if after exposure and washing it is again steeped in the solution of iodine which renders the *unexposed* parts of a dark violet colour.

(*c*) To a saturated solution of bichromate of potassa, add a saturated solution of sulphate of nickel, in quantity more than sufficient to decompose the whole of the bichromate, or 1 drachm of the latter (the potassa) in crystals to 2 drachms of the former, also in crystals. Apply this to the surface of the paper and expose under a negative. The exposed parts become brown and the rest remains yellow, and if now washed in water the result is a positive picture. But if the exposure be continued under the negative beyond the dark stage the browning disappears and the exposed parts are white, a colourless double salt being formed there. When nitrate of silver is applied as a developer the chromate of silver is deposited in the unsunned portions, where the original solution remains unchanged, but not on the whitened parts. Pure water will remove nearly all except the precipitated chromate, which, if thought desirable, may be converted into chloride, and exposed again, and developed as in the usual silver processes. Sometimes the colourless double salt formed will decompose the nitrate of silver, owing to its imperfect formation. The chromate of silver, by which the shadows are represented, is itself decomposed by light, and, therefore, must be changed in some way, before permanence is attained.

(*d*) Dissolve neutral chromate of copper in ammonia. The solution, which is now a mixture of chromate of ammonia and of ammoniacal solution of oxide of copper, is of a green colour, formed by the mixed yellow and blue of the separate solutions. Papers prepared with this behave like those soaked in the chromate of copper.

**Chrysotype Process.** (Gr. χρυσος, gold.) This is one of Sir John Herschel's ingenious processes. The operations are as follow:—

First. Immerse a sheet of paper in a *moderately* strong solution of ammonio-citrate of iron, and dry it in the dark. The strength of the solution should be such as to dry into a good yellow colour, not at all brown.

Second. Expose the paper to light, either in the camera or pressure frame, under a negative, until a very faint impression is obtained.

Third. Brush over the paper a neutral solution of chloride of gold, of such strength as to have about the colour of sherry wine. The picture immediately appears and is rapidly developed to a purple tint.

Fourth. Wash the developed print in several changes of water, and fix it with a weak solution of iodide of potassium: then wash again thoroughly, and dry.

The picture is now finished.

The rationale of the process appears to be as follows:—

The persalt of iron is reduced by light to a salt of the protoxide.

When a solution of chloride of gold is added, water is decomposed, and metallic gold precipitated. The chlorine takes the hydrogen of the water and forms muriatic acid, and the protosalt of iron takes the oxygen and becomes oxidized to a persalt. The precipitated gold forms the purple shadows of the photograph. The iodide of potassium fixes the picture by converting any chloride of gold which may remain in the paper into a soluble double iodide of gold and potassium.

CIRCLE OF LEAST CONFUSION. *See* "Focal lines."

CITRATE OF MERCURY. 3 Hg. O, Ci. This salt is decomposed by light in the presence of excess of nitrate of mercury, like the corresponding silver salt, but more slowly; and pictures may be developed upon it by the protosalts of iron. Also when precipitated with iron from the protonitrate by ammonio-tartrate of iron or other salts of the like composition, it darkens speedily and intensely. The citric acid has a feeble reducing power, and is probably slowly oxidized into carbonic acid and water.

CITRATE OF SILVER. 3 Ag. O, Ci. + H O. This falls as a shining white powder on mixing citrate of soda with nitrate of silver, and has been used as the basis of a printing process, for the particulars of which the reader is referred to the article on printing. Citrate of silver is insoluble in water, but soluble in ammonia, no doubt forming citrate of ammonia and ammoniacal oxide of silver. When heated to 212° in the presence of hydrogen, part of the oxygen of the oxide of silver in the citrate, is converted into water by uniting with the hydrogen, and citrate of the suboxide of silver instead of citrate of the oxide remains. This has been represented as the change which light also produces on this salt, but it is scarcely a satisfactory explanation. It appears more probable that the citric acid is also at the same time decomposed. If half of the oxygen be removed by light, it must either combine in its nascent state with some hydrogen or carbon in the atmosphere, or it must be entirely set free, or it must oxidize the citric acid or the paper. It is easy to account for its being removed by hydrogen and heat to form water, but when it is separated from the silver by light, it is combined, there can be little doubt, with the organic matter present, and the reduction is due to the joint action of the citric acid and light. Citric acid and the other vegetable acids, all partake in a greater or less degree of the qualities of gallic and pyrogallic, and are capable of being entirely oxidized into carbonic acid and water. Heat increases this tendency to oxidation by increasing the affinity of carbon and hydrogen for oxygen or chlorine, and light does the same. Citric acid will reduce the chloride of gold to the metallic state, and combine with the chlorine, and when subjected to heat it undergoes changes analogous to the conversion of gallic into pyrogallic. The decomposition takes places gradually, and by stages, for citric acid in its oxidation is capable of forming a variety of other organic compounds, and the silver is reduced more and more nearly to the metallic state. The tendency of citrate of silver to be decomposed in this manner is shown by the action of heat upon it. The affinity of the carbon and hydrogen for the oxygen of the silver is increased, by heat, so much that when the salt comes into contact with an incandescent body a kind of explosion takes place, and carbon and metallic silver alone remain. Many other organic salts of silver comport themselves after the same fashion. It seems natural to conclude that what takes place here, almost instantaneously, is effected by light, according to its usual mode of acting on organic substances, viz., by a series of gradual and progressive substitutions. The gradual approach to the metallic state, in prints taken on citrate of silver, is proved by the difference observed in the reaction of nitric acid, ammonia, and hyposulphite of soda upon it in the different stages, by the growing indifference to oxidizing-compounds, the greater permanence of the more reduced parts, the greater facility of amalgamating with mercury, and the bronzing or metallic appearance of the strongly sunned portions. The colour also changes from the red which is indicative of organic matter to blue, which is characteristic of metallic silver. No such alteration of properties appears to attend the reduction of pure chloride; it never bronzes, and appears to be resolved at all stages of the exposure to light into chloride of silver and pure metal. The less citrate of silver prints have been exposed to light the more organic matter will continue in combination with the silver, and the more liable will they be to suffer deterioration by the action of elements for which the organic matter has affinity: the colour is a measure of this liability with the same preparations. When ammonia-nitrate is used with the citrate, the image is bluer and more metallic than with plain nitrate, because alkalis increase the affinity of vegetable acids for oxygen, as is seen in the mixture of ammonia and pyrogallic acid. The decomposed citric salt is more or less acid to the organic compounds of silver which are precipitated by the usual developers, and, therefore, attracts them; and as the silver which falls from the more powerful developers is more completely reduced than that which citric acid deoxidizes, the developed prints are more permanent than the sun prints.

Citrate of Silver Printing Processes. These processes only differ from the other printing processes in the composition of the salting bath, in which citrate of soda is substituted for a portion of the salt. The exact proportions will depend upon the kind of effect which it is desired to produce. The effect of adding citrate of soda to the salting bath is as follows:—

When a paper containing citrate of soda is floated upon a bath of nitrate of silver, a double decomposition takes place, nitrate of soda and citrate of silver, together with excess of nitrate of silver being produced. Now citrate of silver is sensitive to light, and is darkened to a red citrate of the suboxide of silver by exposure to light. This organic subsalt of silver is very energetic in producing the various photographic effects due to organic matter in combination with silver. It reddens the tint of the proof, and renders it more vigorous on the surface, and less liable to assume a cold inky tint when toned with sel d'or. But at the same time it renders the paper less sensitive, a fault which is of no consequence when the light is good. On the whole, therefore, the use of citrate of silver in the printing processes may be considered an improvement, when it is required to produce a certain class of effects.

Citric Acid. This acid is gradually formed in lemons and other fruits, by the oxygen of the air acting on the mucilages which are found in the fruits in their less matured condition; just as tannin is converted into gallic acid by the same means. It is precipitated by chalk as citrate of lime, and liberated afterwards by a stronger acid. A gallon of lemon juice gives 8 ounces of citric acid, and at times more. A drachm of lemon juice is, therefore, equivalent to about 3 grains of the acid, and, when lemon juice is substituted for the vegetable acids, this proportion should be remembered. As it contains more oxygen in proportion to its carbon and hydrogen than acetic acid it is a much stronger acid, but weaker than tartaric acid. Anhydrous citric acid, such as it exists in citrate of silver is $C_{12}, H_5\ O_{11} = \text{Ci.} = 165$, but the ordinary crystals contain 4 atoms of water, and are = 201. Other crystals with more and less water may be formed. The usual crystals are soluble in less than their weight of water, and are soluble in alcohol, but not in ether. The dilute aqueous solution, like gallic and other acids, soon becomes mouldy. It unites with three atoms of base to form citrates: sometimes the place of one or two of these atoms of base is supplied by water. It cannot exist without an atom of water, and when this water is taken from it, it is resolved into aconitic acid and hydrated citric or other compounds, or even into oxalic and acetic acids. It is used as acetic acid in photography, and also as a test of iodate of potassa in iodide of potassium, and to form citrate of soda with the bicarbonate of that alkali for the first preparation of printing papers. Papers soaked in a solution of one part citric acid to 10 water will have the particles of metal which are often so annoying, removed as soluble ammonio-citrates if they are afterwards put into dilute ammonia of 20 parts water to one part liquid ammonia. This acid is a weak deoxidizer: boiled with a solution of chloride of gold it removes the chlorine without giving off gas; chlorocarbonic acid is probably formed, for citric acid may be regarded as a compound of oxalic and acetic acids, and water; and oxalic acid $C_2\ O_3$, as a compound of carbonic acid $C\ O_2$, and carbonic oxide $C\ O$; and carbonic oxide in the light unites with chlorine to form chlorocarbonic acid.

**Cleansing.** The cleansing of bottles, papers, stirrers, and apparatus in general, is a matter of essential importance in many photographical operations; and the great rule must be to clean immediately after use, when purity is obtained with much more certainty and much less labour. All dirty glasses, &c., should be immediately put in a particular place and attended to at the first leisure moment. The following directions will be found useful:—

(*a*) *To clean Albumen from Glass Plates.* Use a solution of caustic potash, or ammonia, for albumen is soluble in alkaline solutions; then wash with water; and lastly, with dilute nitric acid and plenty of water.

(*b*) *Collodion Bottles.* Leave the stopper out until the ether and alcohol have evaporated, and the film is hard and horny, when it will be easily removed without any adhering to the glass by means of cold water and a bottle brush. Drain and rinse out with a little alcohol.

(*c*) *Developing Measures and Trays.* Wash well with tow or a rag and common water, then with a little strong nitric acid if the black precipitate has dried in the vessel. The acid should remain some time in contact with the blackened parts, even after they appear clean: lastly, plenty of water and a clean dry cloth.

(*d*) *Gallic Acid and Gallo-Nitrate.* Bottles in which gallic acid has been allowed to become discoloured or mouldy require the use of nitric acid, which decomposes most organic matters, before they are fit to receive solutions of other compounds.

(*e*) *Glass Plates and Vessels.* These should be washed and rinsed, if possible, as soon as they are done with, and before they have got dry: even common water if allowed to dry on them will leave matters which often require considerable force to remove. If plain water will not clean them a little tow and the ashes from the fire will generally remove every thing. Sand or gravel should not be used with white glass vessels, since it always scratches the soft flint glass of which English vessels are made. They must after washing be rinsed, drained, and wiped with a clean coarse cloth. New window glass or crown glass requires particular care in cleaning, and especially, in hot weather. Glass plates which have received pictures before are, contrary to the general opinion, better than new, if carefully cleaned after each experiment. Nitric acid with or without tripoli is the best detergent for new glass: better without tripoli, if possible. If a plate be cold and then take the the breath in an even film, it is clean. If a collodion picture has been developed with pyrogallic acid, it requires only water, but, if, with an iron salt, nitric acid will be necessary.

(*f*) *Grease.* Greasy glasses should not be washed but, in the first place, wiped with tow to remove as much as possible of the grease, and then a dry cloth should be used until the surface appears clean. It should afterwards be washed with nitric acid or caustic potassa and tow which removes the thin film of grease remaining, and it may then be rinsed, drained, and wiped as before. A special duster should be appropriated to remove grease.

(*g*) *Lenses.* Do not use silk, for it is apt to scratch: a soft wash leather, free from the powders used in cleaning it, is best; if the lens be greasy, soft tissue paper will clean it quickly, especially if moistened with a little alkali. Rub off the alkali with fresh paper, and finish with the wash leather kept for this purpose.

(*h*) *Nitrate of Silver Stains.* Nothing is so good as nitric acid for porcelain, or glass. For linen, or the hands, mix together alcohol 10 ounces, iodine ¼ ounce, nitric and hydrochloric acid each ¼ of an ounce. Apply a little to the stain, and when it has become yellow dissolve it out with cyanide of potassium, and wash well.

(*i*) *Papers containing Metallic Spots.* Make two solutions, one of one ounce of tartaric acid in 10 of water, and the other of one fl. ounce of liquor ammoniæ in 20 ounces of water. Let the papers soak in the first for a quarter of an hour one over the other, then place them for a few minutes in the second. Rinse in plain water and hang up to dry. The metal is removed as ammonio-tartrate.

(*j*) *Resinous, Bituminous, and Tarry Varnishes.* As much as possible should be scraped off with a knife; then use tow with a little strong caustic potash or sulphuric acid; rub the glass well, and after a few minutes the resin &c., will wash off with water, and the glass may be cleaned in the ordinary way. Wood spirit is a clean solvent of these substances.

(*k*) *Spots of over-development in Photographs.* The solution given above for nitrate of silver stains has been found to answer, but it requires care in using.

(*l*) *Sulphate of Iron Stains, and Iron Moulds, and Ink Stains.* To remove these from linen make use of a solution of oxalic acid, and from glass vessels hydrochloric.

(*m*) *Sulphuret of Silver Films in Hypo-bottles.* Remove all that can be rubbed off with tow and water and then use nitric acid which will form nitrate of silver: finish with plenty of water.

(*n*) *Turpentine.* Strong alkali and tow will soon soften it so that it will be moveable by water, or perhaps better, sulphuric acid, which will decompose it.

(*o*) *Varnishes and Varnished Collodion Pictures.* These are all easily removed by wood spirit even if asphalt or brunswick black has been applied: or, if time be not pressing, let them soak for some days in water, when the varnish will peel off.

(*p*) *Yellow Lights in Photographs.* A very weak solution of bichloride of mercury will speedily remove the yellow appearance after the hyposulphite of soda is entirely gone, but the prints must be removed immediately on the effect taking place or the picture will be attacked.

CLEARNESS. This quality in a photograph implies the absence of any action except what is induced by the impact of light, the exact amount of exposure, both as to the intensity of the light and the duration of its action, the exclusion of all light except that reflected by the object which is photographed, perfect optical arrangement so that the image is sharp and evenly illuminated, a uniformly sensitive surface to receive the impression, the arrangement of light so that the illuminated object to be taken appears perfectly modelled, and clean, uniform and smart manipulation. The things to avoid are dirty plates, impure chemicals, too weak or too strong solutions, or those of unknown or inconstant strength, too much heat or cold, bad water, dirty hands or frames, and unclean vessels which cause action independent of the light; lenses with foci not coincident or with no sharp focus, and of too short focus, and cameras shaky or not light tight, or not adjusted to the focussing glass, or open in front to rays from any objects beside the one to be photographed, or deficient in means of absorbing the light scattered by the lenses or the mounting, which cause an imperfect image; illuminated smoke or vapours between the object and lens, bright back-ground or sky to the picture, and dew or grease on the lens, which introduce into the camera diffused light that veils the picture; feeble light, or too intense, or not falling up on the object so as to throw out the relief, light coming too obliquely from parts of the object, and exposure too long or too short, which injure the purity of the modelling; and careless, or unequal, or dilatory manipulation which makes one part of the plate more sensitive or develope more quickly than another.

Cliché. The French word for negative, or mould.

Clips. Little clasps made of wood for hanging papers to dry. They are best when they are tipped with shellac or other varnish that the solutions cannot penetrate, and a separate set should be kept for each operation: they should be provided with S hooks of wire so that they may be hung over a line. Such hooks made with black pins or silver wire are very useful substitutes for the clips themselves.

Coal Oil. Coal tar naphtha.

Coal Tar Naphtha. The term naphtha is now generally applied, par excellence, to wood spirit, or pyroxylic spirit, or wood alcohol, by all which names it is called, but besides this wood naphtha there are many varieties of bituminous liquids which are also called naphthas, and to distinguish them from wood spirit, mineral naphtha. Such mineral naphthas are found in the natural state impregnating different kinds of soil, and often containing petroleum or other bituminous substances in solution. Coal tar naphtha is a product of the distillation of pit coal, and resembles the bituminous or mineral naphthas in its composition: these contain only carbon and hydrogen, but pyroxylic alcohol contains oxygen also. The purest mineral naphthas have the formula $C_6\ H_5$. They are used as solvent of bitumen &c., for varnishes, and will not mix with naphtha usually so called.

Cobalt. A metal resembling, in its photographic applications, iron, nickel, and chromium. It is the basis of smalt, and the blue colour of writing papers. Its compounds with sulphur and arsenic have been found to be affected by light.

Cobalto-Cyanogen. This compound is analogous to ferro-cyanogen, and forms compounds, which like the ferrocyanides are decomposed by light.

Coincidence of Foci. *See* "Lens."

Collodion. This viscid solution is one of the most generally used articles in photogenic operations, and is remarkable as the basis of processes of extreme sensitiveness, and giving pictures surpassing all others for generally good qualities. It is a solution of pyroxyline in ether and alcohol, holding also in solution a certain quantity of some soluble iodide, bromide, or chloride, or a mixture of them. The principal points to be attended to in its manufacture have now been determined by long experience and many trials. There are two chemical compounds known by the name of pyroxyline, one in which the vegetable fibre operated upon increases in weight about 75 per cent., and a second where the increase is only about 50 per cent. The first is insoluble in ether and alcohol, and not used by photographers. The second is the soluble compound, and upon its preparation very much depends. Though chemically the same it varies in its properties, and modifies the physical and chemical character of the collodion according to the mode in which it has been made. The physical characters which vary are the fluidity, smoothness, contractility, adhesiveness, softness, porosity, cohesion, strength, and transparency of the film formed when the collodion is poured on a glass: the chemical characteristics of the collodion, which are liable to variation with the pyroxyline, are sensitiveness to light, and the density and colour of the image. As to the film, fluidity, smoothness, softness, porosity, and adhesiveness go together; and likewise glutinosity, coarse cellular structure, horniness, impermeability to fluids, contractility, and want of adhesiveness go together: and as to the chemical qualities, greater sensitiveness to feeble lights characterizes one kind of pyroxyline and the power of giving dense images another. Two circumstances are favourable to the production of good physical qualities, viz., a certain dilution of the acids employed and a comparatively high temperature, and the chemical qualities depend upon the temperature only. When the most concentrated acids are used insoluble pyroxyline is produced: when the least degree of dilution is formed which, with 120° of temperature, gives the soluble pyroxyline, the collodion has the bad qualities of glutinosity, coarse structure, &c., but by gradually increasing the amount of water, added to dilute the acids, the good qualities grow in degree until a limit is reached where the film in setting becomes short, powdery, and milk white, and partially dissolves in the acids: by stopping a little short of this, and increasing the temperature from 120° towards 170°, the physical qualities undergo still further improvement until a limit is also reached in this direction, when the fibre employed again dissolves in the acid. As to the chemical qualities, when the best physical qualities are obtained that acids at 120° will give, it is found that the sensitized film is very quick, but the chemical action is confined to the silver salts, so that the image is weak blue and metallic; the collodion itself is then a kind of organic matter extremely inert and does not combine in any marked degree with the reduced metal, or take part in the reduction. But if the temperature be raised towards 170° the case is different; the collodion exerts a decided chemical influence in the reduction of the silver salts, and behaves in the same manner as albumen, citric acid &c., in sun-printing. The image is at first red, and is capable of becoming very intense and opaque; it is more soluble than before in cyanide of potassium, and in every reaction shows that the silver is now combined with organic matter. If, therefore, collodion be required for "positives," we select that kind of pyroxyline which gives a collodion with the best physical qualities, but organically inert, for by that means we get a more metallic and brighter tone, and the image being less dense is better modelled and rounded. If negatives are desired we use the pyroxyline made with a higher temperature.

Why does the high temperature render the collodion more apt to take part in the reduction of the silver, and to combine with it? Cotton fibre is nearly pure lignin, and the tendency of acids is to cause lignin to pass successively into starch, gum, sugar, glucose, saccharic, and other acids, which have each a greater reducing power than the preceding member of the series, though they resemble each other extremely in their ultimate composition. Heat favours this action of acids upon these organic substances, and the probability is, that when vegetable fibre is submitted to a comparatively high temperature in the making of pyroxyline, some change of this kind may take place, in a greater or less degree at the same time that the lignin is changed by the acid as before. The acid we may suppose first changes the fibre into an isomeric body, more analogous to gum, for lignin and gum are both represented by $C_{24} H_{20} O_{20}$, and then the further substitution of $NO_4$, for a certain number of atoms of hydrogen, completes the change into pyroxyline. This view is confirmed by an experiment, in which a remarkable collodion was produced very fluid, with 30 grains of pyroxyline to the ounce of mixed ether and alcohol. Swedish filtering paper was allowed to lie half a minute in a mixture of equal volumes of sulphuric acid and water, until parchmentized, and then used, as had been previously done, by Mr. Hardwich, for conversion into pyroxyline: the weakest acids, and the highest temperature were resorted to, that it was possible to try. The parchment dissolved for the greater part, but after 2 minutes immersion, the acid, the vessel, and all were plunged into water. Scraps of yellow looking parchment were collected, washed and dried; collodion made with this showed negative qualities in the very highest degree. The image was exceedingly red at first, and could be intensified to almost any extent. Like all organic matter, it was also found to interfere decidedly with the sensitiveness of the film to light, and this more and more the longer the collodion was kept. This really photographic action of collodion cannot be disputed, though it has generally been said that it is inert, and that its good qualities are entirely mechanical. It may be considered as demonstrated, that where intensity of image is demanded, organic matter must take part in it. It might be supposed that this pyroxyline dissolving 30 grains to the ounce, was a different compound from the ordinary kinds: it might have been, but different kinds of pyroxyline have been made dissolving from 1 to 15 grains, which were made without loss, and all of which increased in weight about 50 per cent. in the making, so that they were probably all of the same composition.

With respect to the solvents of the pyroxyline, the ether and alcohol, a similar regard must be had to the kind of collodion required. For collodion positives it is necessary that they should both be free from organic matter, or they will form a collodion not sensible to feeble lights, which will show itself in pictures wanting half tint in the shadows, and overburdened with material in the lights, in fact, too negative. Careful distillation from caustic potash is necessary in this case, and also a prudent choice of alcohol in the first instance. It is extremely difficult to decompose the grain oil, and other matters occurring in some alcohols made from roots and seeds, and they should be rejected for photographic purposes. For negatives it is not essential that the spirits should be perfectly pure so long as they are neutral, and good rectified ether and alcohol will answer well: to make negative pyroxylines, proceed thus:—

Take one ounce of old linen or calico that has been many times washed. Boil it in weak caustic potassa until it ceases to give colour to the solution, and then let it remain as long as convenient in the solution. This modifies it in the same way as linen and cotton fabrics are modified by alkali, when they are intended to be bleached; that is to say, they are rendered more susceptible of oxidation. Then to 10 fl. ounces of sulphuric acid, S. G. 1·84, in a warm basin, add 12 fl. drachms of water, and next 10 fl. ounces of nitric acid, S. G. 1·45. The temperature will probably rise to 140°, or thereabout. If it does not, place the basin in a deep dish containing boiling water until it does, and if it goes beyond that temperature, wait until it cools to that degree. Take the basin if necessary from the hot water, and immerse in the mixed acids the ounce of linen previously washed from the alkali, dried and torn into strips of 6 or 7 inches long, and 2 or 3 wide. When the linen is immersed, the temperature will probably rise to 150°, and if it does not, replace the basin in the hot water. Keep the whole at a temperature of 150° for twenty minutes moving the linen so as to secure uniform reaction. Then pour off the acid, plunge the basin and its contents into a very large vessel of water, and stir it up vigorously. Allow the pyroxyline to settle, and immediately pour off the water; squeeze the cotton and place it in another vessel of water; continue this washing until no acidity is shown by litmus paper, and then allow the pyroxyline to soak some hours in water. Lastly, squeeze well in a clean dry cloth, and spread the pyroxyline in a warm room to dry. It will be found necessary with almost every fresh sample of nitric acid, to try by experiment on small quantities, whether the above proportion is the weakest possible mixture of the acids that will act without dissolving much of the linen. If none at all is dissolved, it is almost certain that more water may be added. The pyroxyline ought to dissolve 6 or 8 grains to the ounce, and give perfect fluidity and a structureless film.

To make positive pyroxyline. Use cotton wool instead of linen. Keep the temperature about 130°, and allow the acids to act for 5 or 6 minutes: it should dissolve 4 grains to the ounce.

COLLODION NEGATIVE PROCESS. In this process a negative photograph is taken on a glass plate coated with collodion. The various operations are as follow:—

*To prepare iodized Collodion.* This is made by adding to plain collodion a certain quantity of an alcoholic solution of iodide of potassium.

To make the plain collodion; dissolve to the ounce of pure ether S. G. 765, (made by adding alcohol S. G. 845 to ether S. G. 720,) about 3½ grains of pyroxyline, or more, according to the nature of the pyroxyline and the kind of film desired.

To make the iodizing solution; dissolve 14 grains of pure iodide of potassium to the ounce of alcohol, S. G. 810. The iodide of potassium is not freely soluble in the alcohol. It must therefore be pounded in a mortar, and the bottle containing the mixture well shaken occasionally, and immersed in a basin of tepid water. All this is very troublesome. The neatest and simplest way of making the iodizing solution is to procure absolute alcohol S. G. 794, which will require about the one-twentieth part of its bulk of water to raise its S. G. to 810. The iodide of potassium may therefore be dissolved in the water, and then added to the alcohol.

The S. G. of the plain collodion is about 769, and of the iodizing solution about 839. These specific gravities correspond with those of the excellent compounds made by Mr. Thomas, and called by him "Xylo-iodide of silver," (which contains apparently neither xyloidin, nor iodine, nor silver,) and solution X; their chemical composition and properties being also apparently identical with Mr. Thomas's preparations.

To iodize the plain collodion; add one part of the iodizing solution to three parts of the plain collodion; shake well together, and use the next day. If used immediately the sensitiveness is at its highest pitch, but sometimes the negative may be a little wanting in density, and perhaps disfigured by minute floating particles which adhere to the film in consequence of the mixture not having been allowed to settle, as well as with minute white spots occasioned by undissolved crystals of iodide of potassium which have been precipitated by mixing the iodizer with the ether, and have not had time to be redissolved.

Iodized collodion deteriorates by keeping, and at the end of a few months is generally unfit for use, in consequence of the pyroxyline undergoing a decomposition which renders the film rotten. It is at first of a lemon yellow colour, which changes in the course of time to a deep red. In this state it is perfectly useless, and should be thrown away, as the ether obtained by redistillation from it is too impure to be used again for a similar purpose. Only small quantities of iodized collodion should therefore be made at a time, and it should be kept in a dark place as exposure to light greatly accelerates its decomposition. The bottle which contains it should be made of orange coloured glass.

The change of colour produced in iodized collodion by keeping is due to the liberation of iodine. This is occasioned, in all probability, by the oxidation of the potassium, which forms potass, and unites with an organic acid produced by the decomposition of the ether, alcohol, and pyroxyline. The photographic effects of old, as compared with new iodized collodion, may be imitated very closely, by adding a little acetate of potass and free iodine to the iodizing solution. The negatives then require a much longer exposure, and exhibit greater density in the blacks, and less gradation of tone, which are the effects produced by old iodized collodion, with the exception, however, of the increased porosity or rottenness of the film in the latter case. When old iodized collodion is used, the free iodine liberates free nitric acid from the nitrate of silver in the nitrate bath, and this lessens the sensitiveness of the film, while increased density is produced by the formation of organic salts of silver, which in all the photographic processes have the property of intensifying the image, as well as in some degree of impairing the sensitiveness of the excited plate or paper.

When iodide of cadmium is used instead of iodide of potassium, the iodized collodion does not become gradually deteriorated in the same way, but the nitrate of cadmium which is formed and accumulates in the nitrate bath has an acid reaction, which like nitric acid, impairs the sensitiveness of the film, and the density of the negative. Iodide of cadmium also injures the fluidity of collodion.

Iodide of ammonium is a very unstable salt, and liable to be decomposed into free iodine and ammonia. Collodion iodized with this iodide becomes rapidly discoloured (particularly in the light), although when first iodized it yields remarkably good negatives. The free iodine introduced into the nitrate bath, and the instability of the nitrate of ammonia which is formed by the double decomposition of nitrate of silver with iodide of ammonium, both tend to overcharge the nitrate bath with free nitric acid. Iodide of ammonium is therefore a bad iodizer to employ for negative collodion, although a very good one for positive collodion, to which the same objections do not apply.

The alcohol used for making negative collodion need not be so absolutely free from the common impurities of alcohol as that which is required for positives, for these impurities act rather beneficially than otherwise in increasing the density of a negative. In positives, however, where density is not required, but a pure white metallic precipitate, they act injuriously on the tone of the picture. Positive collodion should be made with chemicals of the utmost purity, and yet it is generally sold at a cheaper rate than negative collodion.

Photographic pyroxyline is perfectly soluble to a mixture containing equal parts of absolute ether (S. G. 720), and absolute alcohol (S. G. 794); and certain iodides, such as the iodides of calcium, ammonium, or cadmium, which may be used as iodizers, are soluble in anhydrous alcohol. It is possible, therefore, to make iodized collodion which shall be absolutely free from the presence of water. But the film thus obtained, is found to be so extremely repellant of water, that it is impossible either to excite it properly in the nitrate bath, or to get the developer to flow evenly upon it. Water is, therefore, a necessary ingredient in photographic collodion. On the other hand, when collodion contains too much water, the film cracks all over in drying, and the picture is destroyed. Great nicety is therefore required in so regulating the specific gravities of the ether and alcohol as that the collodion shall contain the proper amount of water, and no more.

It is sometimes advisable (in hot weather for instance) to use more alcohol in the collodion, in order to keep the film moist longer, as well as to increase its sensitiveness by modifying its mechanical properties. When absolute alcohol (S. G. 794) is used, considerable latitude is allowable in the quantity which collodion may contain. For instance, if to an ounce of iodized collodion, an ounce of absolute alcohol, and the corresponding quantity of pyroxyline and an iodizer be added, the collodion so made will yield excellent negatives scarcely distinguishable in any respect from the original collodion containing only half the quantity of ether. As alcohol is much less volatile than ether, this seems to indicate that for certain purposes the usual proportions of ether and alcohol may be advantageously modified. In making this experiment the reader must, however, remember that by "absolute alcohol" is meant alcohol S. G. 794. The alcohol frequently sold as "absolute," and even called so by chemical writers who ought to know better, contains as much as 5 per cent. of water, and would, of course, ruin the collodion, if used in the quantity indicated above.

Plain collodion may be kept for a very long time without deterioration, in a cool, dark, dry place. It should be kept in a tall, well-stoppered glass bottle, which should be shaken as little as possible when decanting the collodion, so as not to disturb the particles of undissolved cotton, &c., which settle to the bottom.

When too much iodide is added to collodion the film cannot contain the whole of the iodide of silver that is formed in it by the nitrate bath. It therefore lies loosely upon the surface, or is partially washed off. On the other hand, if the film contains too little iodide, it appears thin and blue when looked at in the light, and does not give quite so intense an image, the sensitiveness being also somewhat diminished, though not much. It is better to have too little iodide in the film than too much.

When too much iodizing solution is added to plain collodion, the film becomes thin and insensitive, because there is not enough pyroxyline and too much iodide and water in it, so that the sensitive iodide is washed off and transferred to the bath. When a film contains too little pyroxyline, and too much iodizing solution, the effect is first indicated by the formation of broad parallel lines or bands, like the edges of retreating waves upon a flat beach, all round the edges of the film; and when this fault exists to a great extent in collodion it becomes hardly possible to obtain a trace of a picture, even after a very long exposure. The remedy is simply to add plain collodion until good results are obtained. This addition of plain collodion to iodized collodion which works badly will frequently remédy the evil. Another cause of the insensitiveness of collodion, and poverty of the negative, occurs when from any mismanagement or inaccuracy in mixing the ingredients the iodide of potassium is allowed partially to crystallize or solidify before the film is put into the nitrate bath. This produces a compact and insensitive coating of iodide of silver, which is blue and not sufficiently transparent by transmittent light. The negative on such a film as this is weak and insensitive. It appears, therefore, that even when the materials are good, a variety of mishaps may occur through mismanagement in combining them.

Having now described the mode of preparing iodized collodion, ready for use, we proceed to the various operations of taking the negative.

*To coat the plate with iodized Collodion.* The plate must first be cleaned in the manner described in the article, "Cleaning," and then well polished with a cambric rag, or leather buff, immediately before pouring on the collodion, for unless the plate is wiped thoroughly dry and well polished before use, it will be covered with streaks or marks where the damp rag last touched it. The breath condenses upon a clean, dry, polished plate in an even sheet, without exhibiting marks or irregularities.

Hold the plate horizontally, by one corner, between the finger and thumb of the left hand, if a small plate, or place it on a plate holder (*see* Plate Holder) if too large to be conveniently held in this way, and pour upon the middle of it rather more collodion than is sufficient to cover it with a good thick layer. Then, tilt the plate so as to let the collodion flow towards the thumb, but without touching it, and afterwards to the other corners in succession, and pour off the surplus into the bottle from the corner opposite to that by which you hold it. This done, keeping the corner of the plate still resting upon the neck of the bottle, and holding it vertically, rock it three or four times quickly through a wide angle, in order, to prevent the formation of lines in the collodion; then place it upon the dipper ready to be plunged into the nitrate bath.

Be careful to wipe the neck of the collodion bottle occasionally, as bits of dry collodion which are formed there are liable to become detached and deposited on the plate; also, avoid dust in the dark room, and blow off any floating particles which settle upon the plate, before coating it.

*To excite the Film.* The ether evaporates very quickly from a coated plate, and the fluid collodion speedily gelatinizes. This is called "setting." When the collodion has sufficiently set, that is, as soon as it ceases dropping from the corner of the plate, and is safely placed upon the dipper, immerse it, without pausing, in the nitrate bath; a pause during the immersion producing a line across the plate. Then, move it from side to side in the bath, for a few seconds, in order to prevent the formation of streaks in the direction of the dipper, and leave it immersed for a couple of minutes or so. Then raise it out of, and lower it into the bath half a dozen times; in order to wash off the ether and get rid of the greasy, streaky, appearance of the film; let it drain for a few seconds over the bath; wipe the back of the plate with blotting paper, and place it in the slide, taking care never to invert the slide while the plate is in it, and thus allow the free nitrate which drains towards the bottom to flow back over the partially dry upper surface of the plate.

The strength and composition of the nitrate bath is a matter of the greatest importance. The formula for making it is simple enough, but the bath is liable to many kinds of irregularities in its mode of action, the principal of which will be described, and the remedies pointed out.

The Nitrate Bath is made by dissolving 30 grains of nitrate of silver to the ounce of distilled water, and leaving an iodized collodion plate in it until the iodide of silver is dissolved out. This may appear simple enough, but a solution of nitrate of silver may be either acid, neutral, or alkaline, and its condition in these respects materially affects the character of the negative.

Crystallized nitrate of silver is generally contaminated with free nitric acid, and frequently adulterated with nitrate of potass. The latter impurity has no other bad effect than that of weakening the solution in which it is substituted for nitrate of silver, but free nitric acid in the bath has a very marked and injurious effect when it exists in too great excess.

Free nitric acid in the nitrate bath impairs the sensitiveness of the film, and produces in a greater or less degree, according to its excess, grey, metallic, and feeble negatives, which it is difficult to intensify sufficiently. A bath containing an exceedingly faint trace of free nitric acid is very good for all purposes where the light is strong, such as views, skies, &c., because it keeps the lights of the negative very clean, at the same time that it prevents the blacks from acquiring an undesirable degree of opacity, but for in-door work it is better to neutralize completely the whole of the nitric acid, and acidify the bath slightly with an organic acid, such as the acetic.

There are three ways of preventing the presence of free nitric acid in the nitrate bath. The first is, to fuse the nitrate of silver; the second to neutralize the nitric acid with carbonate of soda; the third to add acetate or citrate of soda to the nitrate bath.

By fusing nitrate of silver the whole of the free nitric acid is driven off. The salt is then in general rendered slightly alkaline, a fault which may easily be remedied by the addition of acetic acid to the solution; and sometimes, which is much worse, nitrite of silver is formed, in consequence of the presence of nitrate of potass in the silver salt. Heat drives off oxygen from nitrate of potass, and forms nitrite of potass, which in its turn is oxidized at the expense of the nitrate of silver, and nitrite of silver produced. The heat required for fusing nitrate of silver is not sufficient to decompose it and form nitrite. Nitrite of silver is a most objectionable substance to introduce into the nitrate bath. A very few crystals of it added to a large bath will completely put it out of order, and cause it to produce foggy negatives, looking as if they had been exposed to diffused light. Acetic acid will not remedy this evil. The only remedy is to add nitric acid, and so convert the nitrite into nitrate. It appears therefore, that fused nitrate of silver is liable to contain nitrite, and is consequently a dangerous substance to introduce into a bath, unless the purity of the nitrate of silver has been fully established, before fusing it.

The second plan of getting rid of free nitric acid from the bath, is to neutralize it with pure carbonate of soda, a solution of which should be added drop by drop, until the bath becomes decidedly alkaline, after which it should be acidified with acetic acid. This is an excellent mode of dealing with an acid bath.

The third plan is, to add acetate or citrate of soda to the bath. The soda having a stronger affinity for the nitric than for the organic acid, leaves the latter and combines with the former, thus producing nitrate of soda, which is inert, and acetate or citrate of silver, both of which latter salts are slightly soluble in the nitrate bath, and have a marked effect in increasing the redness and density of the negative, and at the same time rendering the film less sensitive.

A bath made with fused nitrate of silver acts very well when the nitrate is perfectly pure, and the alkalinity of the solution neutralized by acetic acid.

The effect of free acetic acid in the bath is to keep the lights clean, and slightly to impair the sensitiveness of the plate.

When a nitrate bath is accurately neutral it gives the most sensitive film, but in this state it is very liable to get out of order, and either become alkaline from the introduction of carbonate of potass with the collodion, or acid from the fermentation of organic matter which it may contain. Acidity is frequently produced in this way when travelling, in consequence of the bath being kept for a long time in a state of agitation.

It is impossible to obtain a good picture with an alkaline bath. The developer is immediately decomposed and a precipitate thrown down all over the plate. The film is not in this case more sensitive than when the bath is neutral.

The acidity of a bath should never be neutralized with ammonia, because ammonia has a strong tendency to escape from its compounds. Carbonate of soda is the proper alkali to employ. When added to the bath yellow insoluble carbonate of silver is formed which is immediately decomposed, and carbonic acid liberated with efferverscence. This goes on until the whole of the nitric acid is neutralized, after which the insoluble carbonate of silver is precipitated. This is again decomposed by the acetic acid afterwards added, and acetate of silver formed.

On the whole it will be seen that the best formula for the nitrate bath is that in which pure recrystallized nitrate of silver is used, containing only a very small excess of nitric acid. The negatives are not then so excessively dense as to produce chalky positives, and the process is generally manageable as regards exposure for out-of-door subjects, where the range of light and shade is the greatest that occurs. When there are moving figures in a view which cannot be taken instantaneously, and when violent contrasts of light and shade occur, an exposure of two or three minutes is far preferable to one of twenty or thirty seconds,—and then this kind of bath will be found the best to employ, for the plate may then be exposed until the picture is covered with detail without any part being overloaded with a dense impenetrable precipitate. Excessive density is the great evil to avoid in negative photography, and beautiful modulation of tone with perfect rendering of all the details the great desideratum; provided always that a proper amount of contrasts between the highest lights and deepest shades is at the same time introduced.

A nitrate bath sometimes works badly in consequence of being too weak. Its strength should be tested occasionally with a silvermetre. *See* "Nitrate Bath."

The Bath may be kept for years in a glass, or gutta percha vessel, when the gutta percha is pure and unadulterated. Porcelain is objectionable, as nitrate of silver acts on the glaze. There is a substance used in America for baths and dishes, called "Photographic Ware," which resembles wedgewood ware, and has no glaze; this is said to answer very well. The nitrate bath should be filtered occasionally.

*To develope the image*—Pour over the plate a solution containing:—

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| Distilled water | 1 ounce |
| Pyrogallic acid | 1 grain |
| Glacial acetic acid | 20 minims, |

or

| | |
|---|---|
| Distilled water | 2 ounces |
| Pyrogallic acid | 2 grains |
| Citric acid | 3 grains. |

It is convenient to make a small quantity of developer of three times the above strength, and to dilute it when wanted. You have, then, at hand a little strong solution to use, should occasion require. The developer will not keep longer than three or four weeks. A little alcohol added to it makes it flow more freely over the plate. It should be filtered if any floating particles appear in it. Citric acid is much cheaper to employ than acetic acid, and it answers very well, giving negatives of a more inky tint than acetic acid; but it must be carefully weighed, as a grain or two more or less may make a considerable difference, citric being a very powerful acid in photography.

Although it is customary to call the acidified solution of pyrogallic acid the "developer," yet it must be borne in mind that this is *not* a developer unless it also contains nitrate of silver. The small quantity of free nitrate of silver which remains on the wet plate is, in general, sufficient to complete the development, but sometimes it is necessary to add a few drops to the developer, towards the end of the process in order to render the negative sufficiently intense; and this addition is always necessary when the bath contains a little free nitric acid. The picture should be developed as soon as possible after exposure, because, as the plate dries, the free nitrate becomes concentrated, and dissolves the iodide of silver, thereby destroying the impression produced by light.

It frequently happens, in hot weather, that the plate gets so dry during the exposure, that it is difficult to make the developer flow over it at once, and this produces stains, which spoil the picture. In such a case the following is a good plan to adopt:—

After removing the plate from the slide, immerse it in a bath of distilled water. Then wash the measure which contains the developer thoroughly in water, afterwards with cyanide of potassium, and then with water again. This renders it chemically clean. Now pour into it the necessary quantity of developer, and add a few drops of fresh nitrate of silver solution. Remove the plate from the distilled water, and develop immediately with the above mixture, which will now flow freely, and the picture will come out as quickly and as dense as before, and free from stains. The developing pyrogallo-nitrate of silver should not become discoloured in the measure. If it does, it is a proof that the measure is not thoroughly clean, and the result will probably be a bad proof, dirty, and stained.

When the details are fully out, and the blacks of the proper intensity, wash the proof with water poured over it gently from a jug, and fix it in the manner to be described.

When a picture has not received sufficient exposure, the blacks become very intense while the lights remain clear and devoid of detail. Under these circumstances it is impossible by any modification of the treatment to produce a good negative. When the picture has been over exposed the effects are different according to the state of the bath and collodion. When the bath is acid with nitric acid, the effect of great over-exposure is to reverse the action of light in the black parts of the negative, and render them more or less transparent. When the bath is acid with acetic acid, and the picture exhibits the effects due to organic matter, the over-exposed parts do not become dark so rapidly as those which have received the proper exposure, but remain red and transparent, having a burnt appearance, the edges of the red parts being, however, fringed with black, and the "solarization," as it is called, being more marked in the centre of the over-exposed part. When the bath is neutral, and the iodizer contains chloride of magnesium, and the developer citric acid, the over-exposed parts are sometimes those which acquire the greatest density and opacity, and what is called "solarization" is not then produced.

Over-exposed negatives give flat and feeble positives, which are deficient in contrast and cannot be properly printed to a good tone.

There are limits therefore to the time of exposure which cannot be passed with impunity. When diffused light finds its way into the camera, fog is an evil which is greatly exaggerated by over-exposure; and when the chemistry of the process is a little at fault, the effects of over-exposure are sometimes very remarkable and absurd.

Negatives may be developed with proto-sulphate of iron acidified with acetic or citric acid; and some persons think this developer a much better one than either of those before described. The proportions are variable, and depend on circumstances. In our hands the following formula succeeds very well:—

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|---|---|
| Distilled water . . . . | 1 ounce |
| Proto-sulphate of Iron . . . | 5 grains |
| Acetic acid . . . . . | 5 minims |

The acid should be added to the proto-sulphate solution immediately before use, and the proto-sulphate solution should be kept as much as possible IN the light. There should be no free nitric acid in the nitrate bath, and the collodion should be such as to assist the production of an organic compound of silver. When this developer is used too strong, a white transparent stain is produced upon that part of the plate on which it is first poured; but so long as this evil does not occur the developer may be strengthened with advantage. The exposure need not much exceed one-half that which is required when pyrogallic acid is used. The chief merit of the iron developer is that it yields negatives abounding in half tone, and with exquisite detail. Any amount of density may be obtained with proper treatment. The negatives are *brown*, and not *blue*.

Some operators commence the development with iron, and finish with pyrogallic acid, the iron being, of course, carefully washed off before applying the pyrogallic. This is an excellent plan.

When the precautions for avoiding "fog" are strictly observed, negatives developed with iron are as perfectly transparent in the lights, as those developed with pyrogallic acid.

On the whole the iron developer appears to be superior to the other, in the hands of a skilful operator; and it is particularly serviceable in cold weather.

As a universal rule, a negative should be red and not grey in the first stage of the development.

*To fix the picture*—Pour over it either a saturated solution of Hyposulphite of soda, or a solution of cyanide of potassium from 5 to 10 grains to the ounce. As soon as all the yellow iodide of silver is dissolved, wash the plate well with water, and set it up to dry.

Hyposulphite of soda does not reduce the density of a red organic image so much as cyanide of potassium, but the plate requires to be washed much more thoroughly and carefully after it, for if this be not attended to, the hypo left in the film is apt to crystallize and destroy the picture.

Collodion negatives are not permanent unless they are varnished. The pyroxyline film is gradually decomposed by contact with air and moisture, and an oxide of nitrogen produced, which destroys the photograph. When properly varnished, however, they appear to be extremely permanent. Good spirit varnish is the best, and amber varnish one of the worst to employ. (*See* "Varnish.") When spirit varnish is used the plate should be warmed before the fire, both before and after the application, but not made too hot, or the negative would be dissolved off the plate. The varnish is poured on in the same way as the collodion. It dries very quickly. Other varnishes are applied in the same way to a cold plate, which should, however, be thoroughly dry.

The negative is now finished.

It may be well to add a few words on the chemistry of this important process, although the general chemistry of photographic processes has been discussed at some length in a separate article on the Chemistry of Photography, *q. v.*

The collodion film is nearly inert, producing in a very slight degree the effects due to organic matter; it must be considered as little more than the vehicle for supporting the sensitive iodide of silver, which is more sensitive to light when precipitated in a test tube, than when collodion is added to it. Collodion is not an accelerating substance; on the contrary, it diminishes the sensitiveness of the mixed iodide and nitrate of silver. The reason why the collodion process is more sensitive than any other, is partly because the film is moist and transparent, and the sensitive chemicals are distributed through it in a finely divided state, and partly because the nitrate bath is nearly neutral, and the developer highly energetic.

The iodide of potassium in the film produces with the nitrate of silver in the nitrate bath a double decomposition, iodide of silver and nitrate of potass being formed. The latter salt appears to be inert in the various operations.

On exposure to light, the iodide of silver and free nitrate in the film are reduced, and an image formed, which, in the collodion process, is too faint to be visible.

The developer, when mixed with the free nitrate on the plate, forms an unstable compound, extremely liable to be decomposed, and only preserved for a few minutes from spontaneous decomposition by the organic acid which is added to it. When this is poured over the reduced image, the reduced particles act as centres of attraction, which first decompose the pyro-gallo-nitrate in contact with them, and then cause it to accumulate atom by atom upon them, in this way causing the image produced by light to acquire fresh material, and become visible and intense.

The fixing solution dissolves the iodide of silver, forming, in the case of cyanide of potassium, a double cyanide of silver and potassium together with iodide of potassium, and, in the case of hyposulphite of soda, a double hyposulphite of silver and soda, together with iodide of sodium.

The exact chemical composition of the blacks of the image is not known. The red substance formed in the early stage of the development is probably an organic subsalt of silver, and the black substance precipitated at the end of the development either metallic silver, or a compound of metallic silver with carbon. If an unvarnished negative be dried before the fire, and then rubbed lightly with a piece of leather, the material of the image exhibits exactly the appearance of polished metallic silver. This is no proof, however, that a small quantity of carbon may not be present, because in the case of steel, (which is a carbide of iron,) the metallic appearance and lustre is perfectly preserved. It is not unlikely that, in the decomposition of gallo-nitrate, or pyro-gallo-nitrate of silver, a compound of meta-gallic acid with suboxide of silver is first produced, and afterwards reduced either to metallic silver, or carbide of silver. The matter is, however, at present very obscure.

Positive Collodion Process. By this process, a direct positive is produced on a collodionized tablet, by developing the image that is obtained in the camera.

The collodion positive and negative processes differ in the following important particular, viz:—

In the negative process the object is to obtain a picture, in which the material of the image shall be more or less *opaque* when looked *through*;—in the positive process, to obtain a picture in which the material of the image shall be a *dead white* when looked *at*. In a negative, density of various gradations is what is required, without any reference to the appearance of the surface deposit. In a positive, *whiteness* of the surface deposit is what is required, without any reference to density. In the negative process, organic matter is introduced, first as acetic acid or acetate of soda in the nitrate bath, and secondly, as gallic or pyrogallic acid, acidified with acetic or citric acid for the developer; the object being to obtain density in the image by combining organic matter with the reduced silver, so as to obtain sufficient opacity, and and not a grey, feeble, metallic image. In the positive process, on the contrary, the object is to *avoid*, as much as possible, the introduction of organic matter in any part of the formula, first by acidifying the nitrate bath with nitric, instead of acetic acid, and secondly, by developing with an inorganic developer, such as a mixture of the proto-salts of iron with nitric acid, and in this way endeavouring to produce not an opaque organic image, brown on the surface, but a thin, white, metallic deposit.

This principle being borne in mind, the rationale of the positive process will easily be understood, and as the manipulation very much resembles that for negatives it may be more briefly described, and the points of difference only between the formulæ indicated. The plain collodion is the same both for positives and negatives, but the iodizing solution for positives should contain iodide of ammonium, instead of iodide of potassium, in about the same quantity, *i. e.* from 12 to 14 grains to the ounce of alcohol. The alcohol of the iodizing solution should be chemically pure, and free from the fusel and grain oil contained in spirits distilled from grain or roots. These organic matters introduced into collodion, although comparatively harmless in negative collodion, affect injuriously the tone of a positive by producing an admixture of organic silver salt with the white metal.

The nitrate bath should be rather stronger in silver than that for negatives, and should be acidified with nitric acid. The formula is as follows:—

| | |
|---|---|
| Distilled water . . . . . | 1 ounce |
| Nitrate of silver . . . . | 40 grains |
| Nitric Acid . . . . . | 1 minim |

The time of exposure is about half that required for negatives.

The Developer is made thus:—

Dissolve one ounce of powdered nitrate of baryta in 16 ounces of distilled water, and add 2 drachms of nitric acid, S.G. 1·4. Next add 1½ ounces of powdered proto-sulphate of iron. Shake well until the iron salt is dissolved. The mixture becomes white and turbid, in consequence of the formation of sulphate of baryta. Let it stand a few hours until this has settled to the bottom of the vessel; then decant and filter the solution, which, if right, will be of an apple green colour. Add two ounces of alcohol to enable it to flow freely over the collodion film. It is now ready for use, but gradually deteriorates by keeping. It may be kept about a month in a cool place. The nitric acid slowly oxidizes the proto-salts of iron and the solution turns yellow. In this state it is much slower in its action, and a little fresh proto-sulphate should be added to it. An ounce of proto-sulphate of iron decomposes about an ounce of nitrate of baryta, forming insoluble sulphate of baryta, and soluble proto-nitrate of iron. The remaining half ounce of undecomposed proto-sulphate of iron forms the energetic part of the developer.

The nitric acid should be added as stated, and not *after* the iron salt as some peroxidation of the iron might then occur, which would occasion a browning of the solution, and be injurious.

The mode of developing the picture is quite different from that in the negative process. It must be done almost at a blow, and is completed as soon as there is a visible indication of the details in the shadows when the plate is laid upon a black ground. These details come out very quickly, and the development generally occupies only a few seconds. If it be carried too far the boldness and vigour of the contrasts is destroyed. Over-exposure produces a blue solarized appearance, as in the Daguerreotype process.

The picture is to be washed, and fixed with cyanide of potassium, then washed again, dried and varnished in the same way as a negative; after which, the back of the plate is to be coated with black varnish. Some operators varnish the picture itself with black varnish because then it is non-reversed on looking at it through the glass; but this is a bad plan, because the varnish injures the tone of the whites, and is very liable to crack and destroy the picture. When applied to the back of the plate, it can easily be rubbed off and renewed if it cracks, and no harm is done to the picture. *See* "Varnish."

Positives should be taken in a non-reversing slide whenever the reversion of the image is objectionable.

Some operators take positives on purple glass, which forms an excellent background to the picture, and renders the use of black varnish unnecessary. This is an excellent plan.

Positives may be taken upon a variety of substances, such as black-varnished paper and card, black-enamelled iron tablets, black patent leather, black glazed canvas &c., &c., Some of these processes are very ingenious and useful, and deserve a particular description

*To take Positives upon Paper, or Card.* The paper or card must first be gelatinized by floating the side on which the picture is to be taken on a warm strong solution of gelatine, and drying it. It is then cut a little smaller every way than a glass plate, to which it is to be attached in the following manner:— Lay the back of the paper upon the glass, heat the blade of a penknife in a spirit lamp, rub it upon a lump of wax, and then pass it quickly all round the edge of the paper so as to fasten it to the glass plate by an edging of wax, without allowing any liquid to get behind it. Next coat the paper with black varnish, and let it dry. Then take the positive in the ordinary way, and when finished cut off the edges of the paper and detach it from the glass. Positives taken on paper or card in this way may be safely transmitted by post. The object of the gelatine is to prevent the black varnish from soaking into the paper.

*To take Positives on Patent Leather, Glazed Canvas, Enamelled Iron Tablets* &c., The leather or canvass is to be attached to the glass by an edging of wax in the manner described for paper, and the positive taken on the glazed surface at once, without black-varnishing it. Enamelled iron tablets may be treated in precisely the same way as a plate of purple glass. The back of the tablet should be varnished so as to prevent its injuring the nitrate bath.

Collodion positives may be transferred to a great variety of tablets by methods which are described in the article on TRANSFERRING. *See* "Transferring."

COLLODIONIZED-PAPER PROCESS. In this process a negative is taken upon a sheet of paper coated with collodion. The process has not yet been extensively practised, but it appears to offer some important advantages, in one or two respects, over every other process now employed by the tourist. It will be better to describe the manipulation first, and point out these advantages afterwards.

The operations in the collodionized-paper process consist in attaching a sheet of paper to a glass plate, coating the paper with collodion, and proceeding in the ordinary way to the completion of the picture; then removing the paper from the glass by soaking it in water, and treating it as an ordinary paper negative.

The only operations we have to describe are those of attaching the paper to the plate, and removing it when the picture is finished; the others being identical with those on collodionized glass.

*To attach the Paper to the Glass Plate.* Immerse it in a warm solution of gelatine, made by dissolving six grains of gelatine to the ounce of water. Let it remain for a minute or two in the solution, then remove it, and immediately apply the back of it to a clean glass plate, pressing it into close contact with the glass by means of a bent glass rod. Let it dry thoroughly. When dry it will stick firmly to the glass.

Coat the paper with collodion, excite it by immersion in the nitrate bath, and develope and fix the picture precisely as in the collodion process. Then soak the plate in water, and remove the paper negative as soon as it will leave the glass without risk of being torn. It should then be well washed in several changes of water, dried, and waxed in the usual way.

The advantages of the process are, that the excited paper is highly sensitive,—more so than an excited collodionized plate,—so that skies and instantaneous pictures may be taken upon it; and, also, that it gives far better definition and half-tone than the ordinary methods upon paper. The photographic tourist may, therefore, employ paper for the same class of subjects as glass, without subjecting himself to the expense, trouble, and risk of travelling with boxes of glass plates, and valuable glass negatives. On the other hand, when all has been done to render a paper negative evenly transparent, it can hardly be rendered *quite* equal to glass for supporting a negative picture. Such are the merits and drawbacks of an excellent process, which deserves to be more extensively practised.

COLOUR.—If the coloured spectrum produced by passing a ray of sunshine through a prism, and thereby decomposing it into coloured rays of different refrangibilities, be thrown upon a sheet of sensitive photographic paper, the paper is most darkened by the violet rays, and least by the yellow and red. This shews that the chemical power of light resides chiefly in the violet rays. Now the colour of an object when illuminated by white light is supposed to depend upon its absorbing all the coloured rays which fall upon it, and, when combined, produce white light, *except* the rays of the particular colour which it emits: so that, on this hypothesis, it might be supposed that the images of yellow and orange coloured objects would scarcely produce an impression upon a photographic tablet, while those of objects of a blue or deep violet colour would produce a comparatively marked effect. This is found by experiments to be true to *some* extent in the case of coloured objects copied in the ordinary way, and to a *greater* extent in the case of light transmitted through coloured media. For instance, if a painting in fresco were exposed to full sunshine, and copied in the ordinary way, the photograph would not be so perfectly truthful in its mode of rendering shade for colour, as an engraving from the same picture, because the yellows and reds would be darker, and the blues and violets lighter in the photograph than in the engraving, in which light colours would be properly represented by lights, and dark colours by shades. But, if the same fresco were faithfully copied by a transparent painting upon glass, and this copy were photographed by superposition upon a sensitive tablet, and a positive printed from a negative so obtained, the untruthfulness of this positive, as regards light and shade, would be much more marked than in the former case. It appears, therefore, that a coloured object emits from its surface certain actinic rays besides the rays of its peculiar local colour, and that the photographic copy of a coloured object obtained in the ordinary way is not *quite* so inaccurate in its mode of rendering colours by shades as might at first be supposed.

As a rule, the photographer should remember that *blues* and *violets* come out *lighter*, and *yellows* and *reds darker*, in a direct, or printed positive, than they ought to be.

It seems probable that different coloured artificial lights, or sunshine transmitted through coloured media, might be successfully employed in illuminating coloured objects to be copied by photography. A variety of highly interesting experiments might be made in this direction, with the view of removing, if possible, from photography the reproach under which it now somewhat justly labours. As yet very little has been done in the way of careful scientific experiments in the photography of coloured objects, and our information is consequently scanty on this head. The difficulty found in copying old oil paintings arises in a great measure from their exceedingly dingy and low tone of colour, which will be perceived by holding a white card against the highest lights; and also from the varnished and uneven surface, texture of the canvas, and other defects.

Yellow paper, or calico, or glass, used for cutting off actinic light, should have a tinge of orange, rather than green, as the red are much less actinic than the blue rays.

COLOURING MATTERS. Organic colouring matters are generally destroyed by the action of light and oxygen, or chlorine. The affinity of the carbon and hydrogen which they contain for oxygen and chlorine is increased by light, and the oxygen which they take up, and which may escape as carbonic acid, alters their composition, and destroys their colour. They have been examined photographically by Sir John Herschel: he found the juice of the red poppy and the double purple groundsel to be especially sensitive to the bleaching power of light, and that the fading of flowers was due to the same cause, which increased in force as the vitality of the plant was diminished. The juices formed in spring, in the more active stage of the plant's growth, are also more easily destroyed when they are expressed, than those which are elaborated at a later season. The colouring matters of leaves go by the names of chlorophyl, xanthophyl, and erythophyl, or green leaf, yellow leaf, and red leaf. A solution of the first in ether passes, by the action of light, into the yellow colour of autumn, that is, into the second variety: the red matter of leaves has already been oxidized, and is much more stable in the air, but long exposure changes it to brown.

These fugitive animal and vegetable dyes have slightly acid properties, like gum and sugar: hence they may be precipitated with the oxides of iron, lead, and aluminium, and, in this state, are much more permanent; and these oxides having an affinity for cotton and other fibres, fabrics may be dyed with these compounds, though they have no attraction for the colour itself, and many of these compounds are purer in colour when formed in the light than in the dark. Many photographic processes are analogous to these.

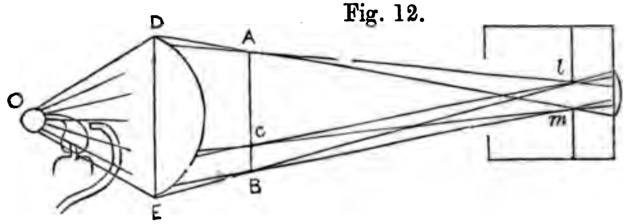
These weak organic acids are, like pyrogallic acid, more easily oxidized when mixed with an alkali, and, therefore, fabrics intended to be bleached are rendered alkaline before they are exposed, by being *bowked*, or boiled, with a weak solution of caustic potassa; and like pyrogallic acid, though in a less degree, they have the power of decomposing solutions of nitrate of silver, and carrying the oxide down.

**Combining Proportions.** *See* "Equivalents."

**Concentrated Solutions.** These are solutions in which the fluid contains as much of the solid matter as it can hold at the actual temperature.

**Condenser.** The condenser is a thick convex lens, of moderate focus, uncorrected either for spherical or chromatic aberration, and used for the purpose of directing light through any transparent object intended to be copied, either in the copying or microscopic camera, in the manner described in the article on copying. Its use and mode of action will be understood from the following diagram. (Fig. 12.)

Fig. 12.

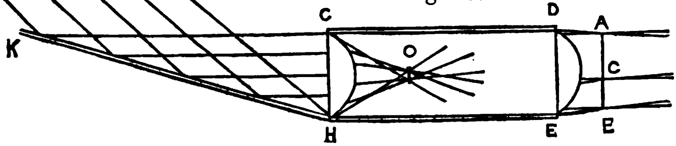


A B is a transparent object to be copied, *l m* the diaphragm of a lens, or the front lens of a combination, O an artificial light (the oxy-calcium light, for instance), D E the condenser.

The condenser is larger than the object to be copied; its principal focal length should be a little shorter than its distance from the incandescent lime ball O; and the image of O should be formed very indistinctly, and with great spherical aberration in the neighbourhood of *l m*. All the rays included within the angle D O E will then be transmitted through A B and the copying lens, and the images of the transparent parts of A B will be formed by diverging pencils, as shown at the points A, C, B, and in the manner described in the article on copying. (*See* "Copying.") The condenser should be of such a form, and be so placed, as to give the greatest possible spherical aberration. Plano-convex is a very good form, with the *plane* side next to the light. Some operators put the *convex* side next to the light, but that is incorrect, because it is required to *increase*, and not to diminish the spherical aberration of the image of O. It is evident that if the lens D E had *no* spherical aberration, the pencils *l* A *m*, *l* C *m*, *l* B *m*, would become straight lines, and the condenser would be useless.

When sunshine is to be used instead of artificial light, the form of the condenser must be modified, so as to suit the parallel rays incident upon it. The construction is shewn in Fig. 13.

Fig. 13.



G H E D is a cylindrical tube, having at each end a plano-convex lens. H K is a reflector, by means of which the sun's rays are directed into the tube. The first convex lens gives a confused image of the sun at its principal focus O, and rays then diverge from O, and pass through the second lens in the same way as from the lime ball in Fig. 12.

A solar camera may be constructed by continuing the ordinary copying camera until the front of it includes the condenser G E, and adding a reflector K H, capable of receiving the same adjustments as the reflector of a solar microscope.

It will be seen in Figs. 12 and 13, that, without the condenser D E, very little of the light that is radiated from O, would pass through the negative and enter the camera through the stop in front of the lens. The condenser collects diverging rays, and causes them to converge to the points desired.

The condenser commonly made by opticians consists of a plano-convex lens, with its convex surface in contact with the most convex surface of a "crossed lens." *See* "Crossed Lens." This arrangement is intended to ***diminish*** spherical aberration, and is therefore wrong in principle. In ordinary lenses, spherical and chromatic aberration are ***defects***, but in a condenser they are ***advantages***. This should be distinctly understood.

CONJUGATE FOCI. It is an admitted principle in geometrical optics, that when a ray of light has passed through any optical instrument composed of lenses and reflectors, it will, on having its direction reversed, return by the same path as that which it previously followed. If, therefore, a pencil of rays diverging from a luminous point Q be refracted through a convex lens, or convex system of lenses, and brought to a focus q, it follows that on reversing the direction of every ray, and considering q as the origin of a pencil proceeding the contrary way to the first, every ray will return by its former course to Q, the origin of the original pencil, which may therefore be considered as the focus corresponding to the origin q. From this circumstance the points Q and q are called "Conjugate Foci."

CONVERSION OF POSITIVES INTO NEGATIVES, AND *vice versâ*. This conversion is often spoken of as possible, but few instances of *true conversion* appear to have been recorded. Collodion positives, and similar pictures, are real negatives, and it is only by reflection that they appear positive. As negatives they are feeble, and the intensifying of them so that they may be printed from is not conversion, but merely further development. In development the last part of the attached silver is more metallic than the first, and a negative has been known to appear very positive by reflection, when much metallic silver has been precipitated upon it; but neither is this a true conversion, it is merely an alteration in the superficial character, and the negative prints as before. When a collodion picture first commences its development, if it be exposed momentarily to daylight, a real positive image by transmitted light is often produced, instead of a negative. But this does not constitute conversion, since no such change occurs when a negative image is once distinctly formed. There are several processes in which, by slight modifications, either the sunned or the unsunned portions may be developed, the darkest at pleasure, so that either a negative or positive viewed by transmission is produced; and in some of Sir John Herschel's processes, the dark parts of a developed negative may be bleached, and the other parts darkened, when a case of real conversion is constituted. Such processes are called Amphitype, (from αμφι both ways).

**Copal.** A resinous substance much used in varnishes. There are three kinds, the East Indian, West Indian, and African. The copal of the East Indies and coast of Guinea is the best. That of India exudes from the *Elæocarpus copalifer*, and is obtained in hard yellow lumps; that of Guinea is found in the sands of rivers.

Copal is soluble in ether, and oil of rosemary, but not very soluble in alcohol, until it has been pulverized and exposed for some months to the action of air and light, by which it is oxidized. Fused copal is soluble in oil of turpentine. Alcohol containing camphor dissolves copal much more readily than pure alcohol. The methods of dissolving copal, and making copal varnish, are described in the article on Varnish; *q. v.*

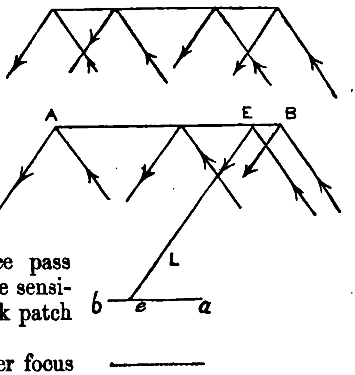
**Copper.** Salts of copper have not been much used in photography. The chloride might be expected to behave something like chloride of silver, since it parts with half its chlorine with tolerable readiness, and is besides prone to oxidation. It has been observed, that the brown chloride becomes blue by exposure to air, and that the whole subchloride absorbs oxygen, and becomes green (Brunswick green). Light would most probably favour these changes. The cupro-cyanides might be expected to act like the cobaltocyanide.

**Copying.** This term is used in photography, when manuscripts, maps, paintings, engravings, and works of art of that class are to be reproduced.

In copying black marks upon a white ground, by the collodion process, it is generally advisable to have recourse to organic matter in the bath and collodion, in order to obtain density at the expense of sensitiveness and half tone. An old and rather discoloured collodion should therefore be used, because it contains an organic salt of potass, and the nitrate bath should be more strongly acidified with acetic acid, and a little acetate of soda added to it. The work to be copied should then be placed either in sunshine or a strong light, and a small stop used to the lens. Care must be taken not to give so much exposure as to redden and enfeeble the blacks of the negative.

A rather strong pyrogallic developer may be used, and a little silver added towards the end of the development. A small stop is necessary in order to give sharpness to the edges of the picture, and a strong light to give density to the blacks of the negative.

The copying of oil paintings is a matter of great difficulty, because reflected light from the varnish is likely to enter the camera and blacken some part of the negative. A lens of long focus should in all cases be employed, for reasons which will be understood by reference to the following diagram, which is exaggerated in its proportions, in order to render it more intelligible.



Let A B be a varnished oil painting, L the lens, and *a b* the image; the lens being one of short focus and placed near to the painting. Suppose the painting illuminated by light falling obliquely upon it as shown by the arrows. Then some of the rays incident about E, will after reflexion at the varnished surface pass through the lens and fall upon the sensitive plate at *e*, producing a dark patch in the negative.

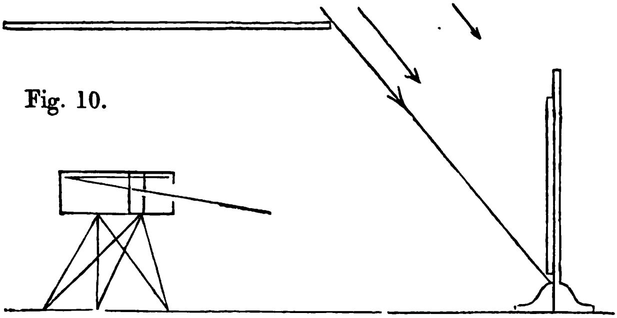
Next, suppose a lens of longer focus used, and the picture placed further from it, the image being the same size as before, as shown by the dotted lines; then, no reflected rays will fall upon the sensitive plate, but they will all pass to the left of the lens.

In copying oil paintings, it is important, therefore, to use a lens of long focus, so as to avoid introducing very oblique pencils. The following is another point of equal importance. If light objects are immediately behind the camera, the light from them will strike the painting nearly at right angles, and then be reflected into the camera. This will be avoided by the arrangement shown in Fig. 10, which explains itself.

Oil paintings should be placed in the sunshine and a stop used to the lens. There is no advantage in using a weak light in photography. A strong light gives a quality similar to that which is called "penetration" in microscopy; that is to say, it brings out the feebler details of objects.

Daguerreotypes should be copied in full sunshine, the original being placed at the end of the projecting front of an appropriate camera, and the light thrown obliquely upon it, (as in Fig. 10,) through an open lid in the top of the box, the inside of the box being blackened, or lined with black velvet.

Fig. 10.

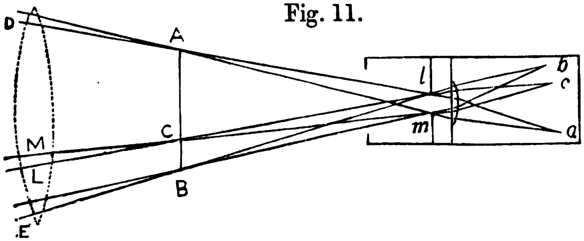


It now remains to add a few words on the mode of copying transparent negatives, by means of a copying camera.

A good deal has been said on this head in the article on the copying camera, (*see* " Copying Camera,") and it only remains for us to discuss the various methods of obtaining a luminous background to the transparent negative. As this is a point which should be thoroughly understood, we shall endeavour to make it as clear as possible with the aid of a diagram. *See* Fig. 11.

The great principle to be borne in mind in the optics of photography is, that the object to be copied is an assemblage of bright points, each of which is the *origin of a pencil* of rays, and that the image formed by the lens is an assemblage of *foci* of these pencils. From every point of the object a diverging *pencil* of rays proceeds, which after refraction through the lens is brought to a focus on the focussing screen. Now, in copying a transparent negative, the case is evidently different from that of copying an engraving or print placed in the same position with respect to the lens. For instance, in Fig. 11; if AB is an engraving and C any white point of it,

Fig. 11.



a pencil of light diverging from C is refracted through the lens, and brought to a focus at *c*;—but if AB is a transparent negative and C a piece of transparent glass, it is evident that C cannot be the origin of a diverging pencil of light in the same way as before, unless rays transmitted through C from a luminous background behind, can be made to intersect at C, and then pass on as if C had been an origin of light.

This being understood, let us suppose that the dotted line DE behind AB is either the sky or an illuminated white screen. Then if C be considered a minute transparent hole, the sky or screen could be seen through it by an eye placed any where between *l* and *m*, and, therefore, rays MC*m*, LC *l*, would intersect at C, and produce the effect of a pencil diverging from C. And similarly of every other transparent point of the negative. It appears, therefore, that when a transparent negative is copied with the sky or an illuminated screen as a background, the same effect is produced as if the transparent parts of it were opaque but luminous, and emitted diverging pencils of light.

In all cases, the diameter of the stop, or lens, is small compared with the distance of the lens from the negative; therefore the angles *l*A*m*, *l*C*m*, *l*B*m*, are small; and if, instead of the sky or an illuminated screen, DE were a convex lens transmitting a pencil of light DAEB, which converges with great spherical aberration towards a focus in the neighbourhood of *lm*, the same effect would be produced as before. A lens of this kind is called a "Condenser," (*See* "Condenser,") and transparent negatives may be copied by means of it, with either an artificial light placed behind it, or reflected sunshine transmitted through it.

When any object is to be copied by superposition in the pressure frame, the ordinary printing processes may be employed which are described in the article on Printing. *See* "Printing."

CORROSIVE SUBLIMATE. Bichloride of mercury; *q. v.*

COSMORAMA STEREOSCOPE. *See* "Stereoscope."

CRIBRIFORM. (Latin; cribs, a gridiron). When a paper negative is viewed by transmitted light, it sometimes appears covered with intersecting diagonal lines, like network. This appearance is called "cribriform." It is produced by the wire frame in which the paper is made, and is generally remedied by waxing the paper properly; but sometimes an insoluble precipitate is formed by the developer in the pores of the paper, and then the cribriform appearance is more marked. Immersion in a bath of dilute muriatic acid will sometimes remove this precipitate, and then by a long immersion in melted wax the paper may be rendered evenly transparent.

**Crossed Lens.** This is the form of single convex lens which has the least spherical aberration. The refractive index of the glass should be 1·5, and the radius of the posterior surface six times that of the anterior surface, both surfaces being convex.

**Crystal Varnish.** *See* "Varnish."

**Curvature of the Image.** This is a term used in optics to denote the fact of an image not lying upon a plane, but upon a spherical or other curved surface.

The "real image," formed by a convex lens, is an assemblage of the foci of pencils which proceed from the various points of the object. The situation of these foci, whether on a plane or curved surface, is independent of the amount of spherical aberration which may exist in each or any of the refracted pencils. "Curvature of the image" is therefore a totally different thing from "spherical aberration," and the terms must not be confounded.

There may be considerable curvature of the image when there is no spherical aberration, and *vice versâ*.

As photographs are generally taken on a flat and not a curved surface, curvature of the image is a very serious evil in a photographic lens. The mode of remedying it by increasing the radius of the field of these instruments, at the expense of other good qualities, is fully described in the article "Lens." *See* "Lens."

**Cyanide of Hydrogen.** An acid resembling the hydrochloric, hydriodic and other acids which are called hydracids, because they contain hydrogen and not oxygen. The hydrogen, however, is not the acidifying principle, but the other element: they ought therefore to be called chlorhydric, iodhydric acid, &c.

**Cyanide of Mercury.** Hg. Cy. This is the usual source from which cyanogen is procured. The attraction of mercury for cyanogen is so strong that peroxide of mercury decomposes nearly all the metallic cyanides, not excepting that of potassium.

**Cyanide of Potassium.** K Cy. The principal employment of this salt in photography is in forming a small proportion of cyanide of silver with the iodide, and in fixing. The former of these uses is not to be commended. As met with in commerce, it often contains half its weight of carbonate of potassa, which is detected by the effervescence produced when an acid is added to its solution: from the usual mode of its preparation, it often also contains cyanate of potass, but not in very large quantity, and this is not injurious. It is deliquescent, and especially so when contaminated with carbonate, but it is not soluble in cold alcohol. By dissolving it in boiling alcohol the impurities are removed, and on cooling, pure cyanide of potassium is deposited. When dissolved in water it may be crystallized in cubes. It is as poisonous as prussic acid (hydrocyanic acid) itself: the best antidote, and one very convenient to the photographer, is protosulphate of iron. It is used from 2 to 20 grains to the ounce of water in fixing photographs, according to the purity of the article. Its properties for this purpose differ from those of hyposulphite of soda, and it is more energetic. Like "*hypo*" it forms double salts with the chloride and other compounds of silver, which contain one equivalent of cyanide of silver and one of cyanide of potassium: they are not decomposed by water as the double salts produced by other fixing agents are, so that no apprehension need be entertained of precipitating cyanide of silver in the washing: and it dissolves much more silver on this account than weak hypo will do. It also acts more quickly; being weak, it is soon saturated, and is more quickly and completely removed by washing, so that very little comparative washing is required. It is never found to crystallize in the film, and but very few instances have occurred in which the washing has been so careless as to leave enough in the film to react on the picture. Cyanide of potassium has also an affinity for oxygen, and has therefore considerable reducing powers, so that the oxides of copper and other metals thrown into it in the fused state, are presently brought to the state of pure metal, and the cyanide becomes cyanate. This reducing power is also seen in fixing collodion pictures, which have a more metallic lustre when fixed with it than when the "hypo" salt is used. All these are important advantages, but it is not adapted to fixing pictures on albumen, paper, and negative collodion, from the power it has of dissolving the organic basis, and reduced silver in combination with it, as well as the unaltered chlorides and other salts. When it is used to fix pictures on the very active negative collodion, which has been mentioned in the article on collodion, it becomes quite red with the organic matter and silver which it removes from the plate, and the picture becomes faint and yellow. The same thing, precisely, occurs when it is used to fix paper impressions, and therefore it is not adapted to these organic pictures. When a collodion negative has density, and to spare, or when the image is blue and metallic, negatives may be fixed with this salt without danger. The solution of cyanide of potassium deteriorates very slowly when exposed to air, by the gradual production of carbonate of potassa.

**Cyanide of Silver.** Ag. Cy. A white salt produced by precipitating nitrate of silver with cyanide of potassium. It behaves like the chloride, but is less sensitive to light, and its use in photography has not been found practically advantageous.

**Cyanogen.** $C_2 N$. This is not an elementary substance, but a compound of two atoms of carbon and one of nitrogen. It behaves, however, precisely like an element, and resembles the group of which chlorine is the most characteristic specimen. It thus unites with hydrogen to form an acid, and with the metals to form cyanides. Its affinity for the less oxidable metals is much greater than that of chlorine.

**Cyanogen Soap.** Soap containing cyanide of potassium.

**Cyanotype Processes.** These are certain processes, discovered by Sir John Herschel, in which cyanogen is employed.

*1st Process.* A piece of paper is first washed with a solution of ferrid-cyanide of potassium, (red prussiate of potass,) and dried. In this state it is of a yellowish colour and highly sensitive to light. By sufficient exposure, either in the camera, or pressure frame under a negative, the salt becomes converted into prussian blue in those parts where light has acted. To fix the picture, the paper must first be soaked in water, then in a weak solution of carbonate of soda, and dried.

Before washing, the shadows of the photograph are of a lavender tint on a yellow ground, but after washing, of a deep blue tint on a white ground. Prussian blue is not a permanent substance; perhaps immersing the papers in tannic acid might blacken the colour and increase the permanence of the precipitate.

The action of light in this process is probably to convert the ferrid-cyanide of potassium into the ferro-cyanide of potassium (yellow prussiate of potass) and form prussian blue.

*2nd Process.* A sheet of paper is first washed with ammonio-citrate of iron, and dried. It is then of a yellowish colour, and sensitive to light. After sufficient exposure in the camera, or pressure frame, *i. e.*, until an image is faintly perceptible, the paper is brushed over with a solution of ferro-cyanide of potassium (yellow prussiate of potass). This brings out the picture of a deep blue tint, which becomes almost black if the paper is allowed to get dry.

The photograph, in this state, is not permanent. It darkens all over *in the dark* by exposure to air. If washed with ammonia, or carbonate of ammonia, it is for a few moments obliterated, but soon reappears with *reversed lights and shades.* In this state it is fixed, and after being thoroughly washed in water, the shadows are pure prussian blue, which deepens by keeping. By this process negatives may be multiplied; but it is so uncertain in its results, as to be of little or no practical value, at present.

The rationale of the process appears to be that the ammonio-citrate of iron, which is a persalt of iron, is reduced by light to a salt of the protoxide. This reacts on the ferro-cyanic salt, and produces the blue precipitate.

*3rd Process.* Brush over a sheet of paper a mixed solution of ammonio-citrate of iron and ferrid-cyanide of potassium, containing about equal proportions of these salts. Dry it in the dark. It is sensitive to light. After exposure, immerse it in water and dry it, when a blue picture will be produced. If this be immersed in a weak solution of proto-nitrate of mercury, it is quickly bleached and destroyed. The mercury salt being then thoroughly washed out of the paper, the picture may be reproduced by ironing it with a very hot iron. The colour is then brown, which fades gradually in the dark, but may be restored at any time by ironing the paper as before.

These cyanotype processes may be greatly varied by substituting for the ferro and ferrid-cyanide of potassium the corresponding cyanogen compounds of many other metals. A wide field is open for experiments in this direction.

Daguerreotype Process. By this process a direct positive is obtained upon a silvered metal plate. It was first published by M. Daguerre, in Paris, in January, 1839.

The picture is produced by means of the impalpable fumes of iodine, bromine, and mercury, acting on a silvered plate which has been polished to the utmost. The photo-chemical reactions consequently occur in an inappreciably small quantity of material, which is spread on the photographic tablet with a uniformity not to be obtained by any other means. Hence it follows that a fine daguerreotype exhibits microscopic perfection of detail, and perfect gradation of shades. Other processes, when compared with this, are coarse and imperfect in the results, and of all known methods of representing a natural object, the Daguerreotype process is the most perfect and scientific.

In a fine daguerreotype, the utmost delicacy of line is combined with perfect gradation of shade; the details of the deepest shadows are as legible as those in full light; and the most elaborate finish is blended with exquisite softness of effect. In tone, nothing can be more beautiful than the varied hues of gold and purple which the image presents when viewed in different positions in a strong light.

Unfortunately, however, the very circumstance which gives such perfection to the result, viz., the polish of the plate, brings with it certain objections in an artistic point of view; and these objections are considered by many to be so serious that they are willing to rest content with an inferior photograph upon a different tablet. Hence the present popularity of the glass and paper processes. But the accomplished photographer, who sees in every process its own peculiar merits, will hardly rest satisfied with a sketchy production, when called on to exhibit the utmost perfection of his art. We would therefore earnestly call the attention of our readers to this elegant and beautiful process, at present so undeservedly cast into the shade by others of less merit.

The manipulation of the daguerreotype process is extremely easy and certain. It involves the following five operations, viz.:

1st.—To clean and polish the plate.
2nd.—To render it sensitive.
3rd.—To expose it in the camera.
4th.—To develop the image.
5th.—To fix the image.

The finished picture is placed in a frame or passe-partout, behind a glass. The image is permanent, and cannot be rubbed out by the finger; nothing but a chemical solvent will obliterate it.

The silvered plates generally employed in this process are manufactured in France, England, and America. The English plates are the best—but they are dear. The amateur had better make his first experiments on the American plates of Scovill and Co., or on the cheaper kinds of French plates, of which there are many varieties. He must choose them as free from scratches and specks as possible, as these defects cannot be remedied. The plates are made by laying a thin sheet of silver foil upon a copper plate, and then passing it between rollers, by which means the two metals are made to adhere perfectly. The silver should contain no alloy. When the same plate has been used several times, the silver wears off, and the plate should then be re-silvered by the electrotype process; but all scratches and specks are faithfully copied, so that this process does not afford a remedy for these defects. A scratched plate is useless, except for experiments. The plates may be cut to any shape by a strong pair of scissors.

In what follows, the plate is assumed to be the quarter size.

*1st Operation.—To Clean and Polish the Plate.*—If necessary, cut a little bit off each corner, and bend the edges in a plate bender.

To clean the plate, procure some Canton flannel, and a box of prepared rotten stone with a muslin strainer. In a pint bottle mix one part nitric acid and twenty parts distilled water.

If the plate has been used before, and has been submitted to the gilding solution, the image must be removed by a liquid sold under the name of "Gilding Dissolvent;" the directions for using which will be found on the label of the bottle.

If the plate has by accident been in contact with mercury, it must be heated over a spirit lamp until the whole of the mercury has been volatilized and expelled.

Then proceed to clean it in the following manner:—

Cut the Canton flannel into pieces about two inches square. Lay one of them on the plate, and pour on the back of it a few drops of dilute nitric acid; rub the damped flannel all over the plate, going well up to the corners. Then powder a little rotten stone on the plate, and rub it all over with the bit of flannel, with a circular motion, until it is *clean.* Beware of scratching the plate. By scratches are not meant the fine circular marks left by the rotten stone, and which are removed on the buff, but the deep cuts made by a crystal of sand or dust on the flannel. When the plate is clean, it presents the grey appearance of unpolished silver, and is free from stains or marks. When you have cleaned the face of the plate, clean the back with the same piece of flannel, and then with a fresh piece of flannel rub the face again until it is dry. The clean plate must not be touched by the fingers.

To polish the plate, procure some prepared charcoal and a couple of buffs. Tie up about an ounce of the charcoal in a piece of cambric, and keep it in a box with a lid, in order that no dust may stick to it. The buffs are made in the following manner. Procure two pieces of wood 16 inches long, 6 inches wide, and 1 inch thick. Screw a strong handle on the back, at the end of each. Cover one with fine velveteen, and the other with cotton velvet. The cord of the velveteen is to be put *across* the buff. When not in use keep them face to face.

Powder some charcoal all over each buff with the dabber, and rub them together. Then, taking the velveteen buff in the left hand, and resting the end of it on a table, lay the clean plate face downwards on it, and with the fingers of the right hand on the back of the plate, rub it up and down the buff vigorously, in every direction, sideways, longways, diagonally, until you have polished it, and removed the circular marks of the rotten stone. Change continually the position of your fingers on the back of the plate, and in order to prevent them from slipping off on to the buff, breathe on them occasionally, or wear a leather glove. If they slip on to the buff, immediately powder some charcoal upon the spot.

When the plate is thoroughly polished it looks black, and not grey. Polish well up to all the corners and edges, and then put it away into the plate box. Clean and polish enough plates for the day's use, before proceeding to manipulate. A plate may be cleaned and polished in two or three minutes in the manner described, but it is hard work, and may be handed over to an intelligent assistant. The remaining processes are extremely neat and elegant; much more so than the collodion or paper manipulation.

*2nd Operation.—To render the Plate Sensitive.*—Powder some charcoal upon the velvet buff, and rub the polished plate lightly up and down for half a minute. The fine lines left by the buff across the plate, must be horizontal, when you are looking at the picture; remember this when giving the last rub to the plate.

The plate is now ready to receive the sensitive coating.

Procure a double coating box, containing two compartments, one for iodine, the other for bromide of lime, and furnished with reflectors. See that the sliders fit air-tight over the glass pans. Put an ounce of iodine into one pan, and four ounces of bromide of lime into the other. Spread them evenly over the bottom, and lay some cotton wool thinly divided over the iodine, in order that the fumes may be filtered, as it were, and rise more equally.

Place the coating box between yourself and a small window, shaded by a white blind, and open the back shutters of the coating box so that a feeble white light may enter, and be reflected from the mirrors.

Place the plate face downwards over the iodine, draw out the glass slider, and observe by means of the mirrors the changes of colour which the plate assumes. These occur in the following order, viz., pale yellow, deep yellow, rose colour, steel colour, the original colour of the plate; after which the colours recur in the same order as before.

Leave the plate over the iodine until it assumes the deep yellow colour bordering on rose. This may occupy from one to three minutes, according to circumstances. Then pass it on to the bromine. Leave it over the bromine until it assumes a blue steel colour. This may occupy from twenty seconds to two minutes, according to circumstances. Then shut the back shutters of the coating box, and draw a yellow blind, formed of three layers of yellow calico, before the window. Return the plate to the iodine, and let it remain from ten to twenty-five seconds, according to circumstances.

The white light which falls on the plate while you are observing the colour, produces an effect, for the plate is certainly sensitive at that time, but the second exposure to iodine obliterates that effect, and renders it harmless. If therefore any accident occurs in taking a picture, even should it be exposed to broad daylight in its sensitive state, the effect of the light may be obliterated by exposing it once more for a few seconds to iodine. The plate need not be cleaned, polished, and sensitized again.

The plate is now ready for the camera, and the sooner the picture is taken the better. It may, however, be kept in a sensitive state for some hours, when proper precautions are taken.

*3rd Operation.—To Expose in the Camera.*—The exposure in the camera is effected in the usual way. The time of exposure is a matter which can only be determined by trial. The details in the deepest shadows may always be obtained by sufficient exposure; it is a mere question of time; but the lights become blue and solarized by over exposure. It is difficult, therefore, to include successfully very violent contrasts of light and shade, and this should not be attempted as a rule, for the great charm of this process consists in the beauty of the half tones. In landscapes, however, the blue solarization of the sky is an improvement to the picture, and the blue tint generally softens down to a warmer tone on the horizon, which gives a very charming effect.

*4th Operation.—To develop the Image.*—Employ a mercury box of any shape, provided with a thermometer. Filter about a tablespoonful of mercury into the pan, through a filter with a very small bore, but do not let the filtered mercury fall from a height into the bath, as it oxidizes in passing through the air, and the globules on reuniting become covered with a grey film of oxide, which floats on the top, and prevents the vapour from rising so quickly as if the surface were clean.

No picture is visible when you remove the plate from the camera. Place it over the mercury, and heat the mercury with a spirit lamp to a temperature of about 140° Fahrenheit. In a few minutes the picture will be developed. The time will depend entirely on the size of the box, a large box requiring more time than a small one. From three minutes to a quarter of an hour are about the extreme limits of the time required. Remove the plate and examine it now and then by a yellow light. Push the development as far as possible, in order to get out all the details. If you over-develop the picture, or much overheat the mercury, the shadows will be covered with minute specks or pellicles. If the plate has been exposed to too much diffused light, a white film of mercury will be deposited upon it, which will obscure the details, or injure the vigour and intensity of the blacks. If you under-develop the picture, the lights will want solidity, and the details of the shadows will be defective.

When the image has been developed in the mercury box, the plate may be exposed to moderate daylight; and the fixing process may be deferred till a convenient opportunity.

*5th Operation.—To Fix the Picture.*—The fixing process includes two operations. The first consists in removing the coating of iodine and bromine, by means of hyposulphite of soda. The second consists in gilding the image by means of a hot solution of sel d'or, which has the effect not only of improving the tone, but also of cementing the image firmly to the plate, so that it cannot be rubbed off with the finger.

Make a solution of pure hyposulphite of soda in distilled water; the strength is not material, say one ounce hypo to ten ounces water. Filter it carefully into a small upright glass bath, like that used for nitrate of silver. Hold this obliquely in the left hand, and let the plate slide in, with its back on the under side of the bath. We recommend this mode of immersing the plate in the hypo, because if the plate is immersed in a horizontal bath, it sometimes happens that two waves of fluid meet in covering it, and this forms a line across the picture, which cannot afterwards be removed. If the back of the plate is dirty, it contaminates the hypo, and occasions stains on the face; hence the importance of cleaning the back of the plate. The hypo very quickly removes the steel colour of the iodine, and leaves the mercury, which forms the lights of the picture, adhering to the silvered plate, the black polished silver forming the shadows of the picture. When the steel colour has disappeared, pour the fluid into the funnel, let the plate slide out of the bath into your hand (taking care that the face of the picture does not touch the glass), then holding it horizontally, pour upon it filtered rain-water, from a bottle having a cork into which a small glass tube is inserted. This washing removes the last traces of hyposulphite of soda.

In this state, the picture may be easily wiped off the plate.

The next operation consists in gilding and fixing the picture.

Place the plate (still wet) on a levelling stand furnished with screws. Then pour upon it the following solution of sel d'or:—

20 ozs. distilled water,
1 gramme (15 grains) sel d'or.

Pour the solution into a small funnel having a tuft of cotton wool in the neck, and let it filter drop by drop upon the plate. Cover the plate with as much fluid as it will hold.

Light a spirit lamp with a large wick, and holding it underneath the plate, heat the fluid to the boiling point. Do not let the flame remain for two seconds on the same spot, but pass it rapidly from place to place, and from corner to corner. Watch the changes of tone which the picture assumes. After a few seconds it darkens slightly, and then begins to clear up. The lights become whiter and the shadows blacker. After a time bubbles show themselves in the boiling fluid. The toning and fixing has now about reached its maximum. Do not let any bubbles adhere to the plate; a spot would occur wherever this happened. To prevent this, strike the table every now and then with your left hand, to communicate vibration to the plate, and detach the bubbles.

When the picture has been sufficiently toned, take it by one corner in a pair of nippers and pour off the fluid. Pour on it distilled or filtered rain water out of a bottle as before, and then dry it by applying a spirit lamp to the back, in the following manner:—

Hold it in the nippers, inclined at an angle of about 45° to the floor; begin with drying the upper corner, and proceed gradually downwards. As the fluid dries off, a line of wet gradually recedes downwards before the lamp; follow this up by blowing on the plate, and remove the last drop from the lower corner by a piece of blotting paper.

If the amateur finds a difficulty in drying the plate, he may let it dry spontaneously, in a vertical position, resting on blotting paper.

The picture is now finished. It cannot be rubbed off with the finger; it is fast and permanent. Put it at once in the passe-partout. But before sealing it up, blow off any dust there may be upon it, by means of an indian rubber syringe, kept for the purpose.

It sometimes happens that the plate on drying becomes covered with minute black spots. These may be removed by a very simple method. Immerse the plate in water, put it on the levelling stand, and pour on it a dilute solution of cyanide of potassium. This will remove the spots. Wash it in water, and dry it as before. Some operators fix with cyanide instead of hypo.

The room in which the plate is sensitized should not be colder than that in which the picture is taken, or than the external air when taking a view; for if a cold plate be taken into a warm situation the dew condenses upon it, and although a picture may be obtained in the mercury box, (and apparently a good picture,) it is nevertheless impossible to fix or tone that picture properly, and it assumes a greenish tint, and is easily rubbed off the plate.

In order fully to appreciate the beauty of a daguerreotype, it should be viewed in sunshine with your back to the light. The ultimate tint depends in great measure on the observance of the proportions of iodine and bromine in the sensitive coating.

A daguerreotype is permanent; the picture cannot be rubbed off the plate; the plate cannot be broken by accident; the picture will bear microscopic investigation. Other processes have their merits, but this is the triumph of the photographic art, and a boon to science.

The theory of this process is so exceedingly obscure and uncertain that at present any attempt at explanation of it must involve much that is hypothetical.

The sensitive film is supposed to be at first in an amorphous state, but to be crystallized and roughened by the action of light. The mercurial vapour adheres to this roughened surface and forms the lights of the picture by amalgamating with the silver. The iodine and bromine are removed by the hyposulphite of soda. The boiling solution of sel d'or appears to act by elective affinity, in the following manner:—Sel d'or is a double hyposulphite of gold and soda. An atom of silver of the plate changes places with an atom of gold of the solution. The sel d'or therefore becomes converted into a double hyposulphite of silver and soda, and gold is precipitated. The gold, silver, and mercury form an amalgam which adheres tightly to the plate, assisted perhaps by the expansion and subsequent contraction of the metal on cooling. This forms the lights of the picture, purple under one aspect, and golden under another. The shadows, where no mercury exists, are blackened and enriched by the precipitation of gold.

Such appears to be the theory of this very beautiful process.

**DAMASKEENING.** This is a process for ornamenting the surface of polished iron, steel, or other metals, with various devices in a different metal either deposited upon, or inlaid in the surface to be ornamented. It has been attempted lately in France to employ photography in this process, but as yet the results obtained are too imperfect to render any account of the experiments necessary or desirable in this place. Still, this application of photography may one day be sufficiently perfected to open an important branch of industry.

**DAMMAR.** A white resin brought from India, where it is used for various economical purposes. It is the produce of the *Pinus dammara* or *Shorea robusta*, and contains two parts, one soluble in alcohol, the other not. It is soluble in benzole, and makes an excellent varnish for positives and negatives on glass. *See* "Varnish."

DARK LINES OF SPECTRUM. *See* "Spectrum."

DECOLORATION. Solutions which have become discoloured by organic matter may be decolorized by mixing with them animal charcoal, or kaolin, shaking up well together, then allowing the kaolin to settle, and carefully decanting the liquid. The nitrate bath used in printing positives, particularly on albumenized paper, soon acquires a brown tint, which may be removed in this way. Kaolin is the best substance to employ. In the case of charcoal, certain physical conditions are necessary, in order that it may possess decolorizing properties. It should be porous, minutely divided, and of a dull aspect. The decolorizing property is chiefly possessed by charcoal obtained from animal matters, vegetable charcoal having but little efficacy in this respect. There is, however, an important objection to the use of animal charcoal, for it not only withdraws organic colouring and odorous matters from solutions, but has also the property of abstracting certain inorganic salts from their solutions. It should therefore be used with caution. Kaolin is certainly preferable to it. Pipe clay, and fullers' earth, have also been used as decolorizers; *q. v.*

DELIQUESCENCE. When a salt becomes moist by exposure to the air, it is said to "deliquesce."

DEPTH OF CHEMICAL FOCUS. Suppose a small direct pencil of white light to be refracted through a single convex lens. Since white light is not homogeneous, but composed of rays of different refrangibilities, the pencil will be decomposed by refraction through the lens into pencils of the various colours of the spectrum, red, orange, yellow, green, blue, indigo, violet; and each of these pencils will have its particular focus, the red being furthest from and the violet nearest to the lens. Let *r*, *o*, *y*, *g*, *b*, *i*, *v*, be these various foci arranged in the order in which they occur. Then, as the red, orange, and yellow rays have little or no chemical action, that action commencing with the green and terminating with certain invisible rays beyond the violet, the space between *g* and a little beyond *v*, is called the DEPTH OF CHEMICAL FOCUS of the lens. In a single lens this depth of chemical focus is so considerable that the lens cannot be said to have any true chemical focus, and a sensitive plate may be placed anywhere within a certain space lying between *b* and *v*, and equally good (or equally bad) pictures may be obtained.

When a lens is corrected, as it is called, for chromatic aberration, by combining TWO lenses of different kinds of glass, TWO of the foci, *y* and *v*, for instance, are united, and the other foci are brought nearer to this combined focus *y v*. The depth of chemical focus is, therefore, greatly diminished, and the point where the maximum of chemical action takes place is also that of the maximum of luminosity of the image. When THREE lenses of THREE different kinds of glass are used, THREE of the coloured foci may be combined; and with *n* lenses *n* foci.

When the greatest possible amount of sharpness of a photograph is desired, depth of chemical focus must be considered a defect, but when a tolerable average of definition has to be struck between the images of objects at very different distances, a little depth of chemical focus in the lens may be tolerated, because a picture in moderately good focus all over may be considered better than one which is very good in one part, and very bad in another. In general, however, depth of chemical focus must be considered a defect. A single lens is comparatively useless for photographic purposes, because of its great depth of chemical focus.

**DEVELOPMENT.** It is somewhat difficult to give an exact definition of this term, as used in photography. If it is defined to be the production of a visible picture from an *invisible* impression, then the term would not include the case of the printing processes in which a faint *visible* image produced in the pressure frame is intensified or developed with gallic acid. If, on the other hand, we consider development to be merely an intensifying process, then all the various methods of *toning* would come under the head of *development*, which would lead to confusion, and be objectionable. Suppose, then, we define development to be the process which immediately follows exposure, and which renders the picture visible in all its details.

In all the common development processes the image acquires fresh material. In the case of the daguerreotype process that material is mercury; in the negative processes with the salts of silver, it is silver, or silver combined with organic matter; in the chrysotype process it is gold; and so on. But the principle on which development proceeds is different in different processes. This will be understood by a few examples.

If a design be traced with the finger on a window pane, and we then breathe on the glass, the dew condenses on those parts which have not been touched by the finger. The design is therefore developed by steam, and rendered visible, dew being deposited on some parts of the glass and not on others; in other words, material is added to some parts and not to others. If an iodized silver plate is exposed in the camera, and then submitted to the vapour of mercury, the vapour adheres to those parts of the plate which have been modified in some way by the action of light, but not to the parts where light has not acted. The lights of the picture are therefore "brought out" or "developed" by the mercury; that is to say, the lights acquire fresh material, which renders them visible.

In the case of a collodion negative, light affects in some way those parts of the film on which it acts; a solution of a deoxydizing body, such as proto-sulphate of iron, or pyrogallic acid, is then poured over the plate; this mixes at once with the free nitrate of silver on the plate, and would at once decompose it and precipitate silver indiscriminately all over the film, were not that effect prevented for a time by acidifying the developing solution with acetic acid. We have then an acidulated mixture of the proto-salt of iron or pyrogallic acid with nitrate of silver floating upon a film, parts of which have been acted on by light. Now these parts have the property of decomposing the unstable fluid in contact with them, and of attracting in this way a precipitate of silver (or of silver combined with organic matter), which is thrown down upon *them only;* so that a visible picture is produced by *the addition of fresh material* to the parts where light has acted.

The same thing happens in the chrysotype process, although in this case the developer is not a deoxydizing but an oxydizing substance. In this process a sheet of paper is first impregnated with a persalt of iron or uranium, (the per-oxalate, or ammonio-citrate of iron, or the nitrate or tartrate of the sesquioxide of uranium,) and then exposed to light. The metallic salt is deoxydized by light, and reduced to a proto-salt, a faint visible image being produced. The picture is then immersed in a solution of chloride of gold, which is an oxydizer, for it parts with oxygen from the water to the reduced iron salt. The liberated hydrogen unites with the chlorine, and metallic gold is precipitated of a dark purple colour. Here then again the picture is produced by the addition of material to the parts where light has acted.

Should, however, any process be discovered in which a developer acts by *withdrawing* material from the sensitive film, that would not invalidate the definition we have given of development.

In the collodion process, both positives and negatives may be produced by development. In the case of a positive the picture is looked *at*, and the precipitated metal which forms the lights must be *white.* This is effected by acidifying the nitrate bath and developer with *nitric* acid, which causes pure white silver to be thrown down uncontaminated with organic matter. In the case of a negative the picture is not to be looked *at* but printed *through*, and the precipitated material must possess sufficient density to stop the light from passing through too readily. In this case it is found that organic matter must be combined with the silver thrown down. This is accomplished by using an organic acid, such as acetic or citric, instead of an inorganic acid, as nitric. In the negative process the dark parts of the picture should at first be red, and should then slowly acquire density and pass ultimately to a brown or purple black. This red tint, in the early stage of the development, indicates the presence of a reduced *organic* salt of silver, which acts powerfully in attracting more material to itself. When the picture comes out grey at first instead of red, this indicates that the material is more metallic and contains less organic matter; it cannot then be easily intensified to a proper degree. When organic matter is introduced too freely in the positive collodion process the lights of the picture are brown or drab, instead of white, which interferes greatly with its beauty, although in detail and gradation of shade it may leave nothing to be desired.

DEVIATION. When a ray of light is refracted or reflected at the surface of any medium, and follows a different course to that which it had before, the angle through which it is turned out of its original path is called its deviation. For instance, if QR be a ray of light incident on the surface of a medium at R, and RS its path after refraction or reflection at R, then, if QR be produced to T, the angle TRS is the deviation of the ray.

The term "deviation" must not be confounded with "aberration."

DEW; DEW POINT.—When a glass of iced water is brought into a warm room in summer, dew is deposited upon it, from the condensation of the aqueous vapour in the air by the cold glass. For the same reason, if a cold glass lens be taken into warm air, it becomes covered with dew, and this interferes with the production of a sharp, clear picture. Sometimes a patch of dew on the middle of a lens will produce a patch of indistinctness and fogginess in the centre of the picture. It sometimes happens also in the paper processes, that when the excited paper is placed in the slide *behind* a glass, instead of being attached to the *front* of it, the cold glass becomes covered with dew on being taken into the warm air, which of course ruins the picture if exposed before the dew has evaporated. In the daguerreotype process also, if a cold plate is placed in summer over a warm solution of bromine, or if a cold iodized plate is taken into the warm air, dew condenses upon it, and this interferes with the production of a fine picture.

The dew point is the temperature at which dew begins to be deposited; it varies according to circumstances. The temperature of the lens, at the time of using it, should be above the dew point.

DEXTRINE. (Latin, dexter, right). When starch is heated carefully until vapour rises from it, it becomes soluble both in cold and hot water, and loses its gelatinous character. Starch thus altered in character is called "dextrine," or "British gum," or "torrefied starch." It has the property, when acted on by polarized light, of turning the plane of polarization to the right; hence its name.

Dextrine of a pure form and very white may be made by moistening 1000 parts of dry starch with dilute nitric acid, composed of 2 parts concentrated acid, and 300 parts of water. The mixture is made into small blocks, which are first dried in the air, and then in a drying stove exposed to hot air, at a temperature of 150°. They are then pulverized, and again dried at a heat not exceeding 230°.

Another mode of producing dextrine is by the action of diastase. Dextrine is also produced by the protracted action of dilute acids at a high temperature upon starch.

Dextrine is of a pale buff colour, insoluble in alcohol, and not blued by iodine. It is a valuable substitute for gum, being more flexible and less brittle when dry. It is applied to the back of postage stamps.

Dextrine and starch have the same chemical composition.

DIAMOND CEMENT; Chinese Cement. Soak isinglass in water until it is soft; then dissolve it in the smallest possible quantity of proof spirit, with the aid of a gentle heat. In 2 drachms of this dissolve 10 grains of ammoniacum,* and while still liquid, add a solution of 2 drachms of mastic in 3 drachms of rectified spirit; stir them well together, and put the mixture into small bottles, which are to be kept covered.

When used, the cement is to be liquefied by putting the bottle into hot water. The oftener it is heated, the better it gets. It resists the action of water.

DIAPHANOSCOPE. (Gr. *διαφανος*, transparent; *σκοπεω*, I see.)

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* Ammoniacum is made by mixing 8 ounces of carbonate of ammonia with 2 drachms of ethereal animal oil.

A dark box for exhibiting transparent pictures, with or without a lens.

**Diaphragm.** (Gr. διαφραγμα, a partition). A partition with a hole in it, used in various optical instruments.

**Diapositive.** A positive intended to be viewed by transmitted light.

**Diathermanous.** (Gr. δια, through; θερμη, heat.) Heat can be transmitted through certain bodies almost without impediment, just as light through glass. These bodies are not necessarily transparent, or diaphanous, but are sometimes partially opaque to light. They are said to be " diathermanous."

Rock salt is the most diathermanous substance known; it transmits 92 per cent. of the heat rays, from whatever source they may be emitted. Sulphate of copper, which is transparent to light, is " athermanous," or opaque to heat.

Rock salt is the " true glass of radiant heat." It can be cut into lenses and prisms, and used for decomposing heat by double refraction, &c.

**Diffraction.** *See* "Light."

**Dimorphous.** Substances which exist in two different forms are said to be " dimorphous." Solids sometimes change their molecular arrangement, and become dimorphous. The axles of railway carriages are made of tough fibrous wrought iron, but by friction, vibration, and changes of temperature, they become crystalline in structure, and brittle. This is an example of dimorphism.

**Dipper.** The holder for the glass plate when immersed in the nitrate bath. It is sometimes made of silver wire, with hooks at the bottom to hold the plate, but more commonly of glass. For this purpose a strip of *plate* glass should be used, about one-third the width of the plate, and an inch or two longer than the depth of the bath, and having a strip of glass cemented across it at the bottom to receive the glass plate. The cement generally used is marine glue, but shellac, or sealing wax, answers very well, and if these are not at hand, spirit varnish may be used. The end of the dipper, and also the cross piece, should be heated with a spirit lamp, or before the fire, and the cement applied, the pieces being pressed into close contact while the cement is hot and perfectly fluid.

**Dispersion.** This term is used in optics to denote the separation of a ray of heterogeneous light, by refraction, into its component rays of different refrangibility.

Different transparent media have different dispersive powers, that is, different powers of widening the angle between the red and violet rays, after the refraction of a ray of white light through a prism of given angle, at a given angle of incidence. In optical formulæ the measure of the dispersive power of any medium is a fraction, the terms of which are determined as follows:—

Let $\mu_v$ be the refractive index for the violet ray.
$\mu_r$ for the red ray.
$\mu$ for the ray of mean refrangibility.

Then, the measure of the dispersive power of the medium is the fraction

$$\frac{\mu_v - \mu_r}{\mu - 1}.$$

| | | |
|---|---|---|
| The dispersive power of | chromate of lead is . . | ·4 |
| „ „ | phosphorus . . . . | ·128 |
| „ „ | oil of cloves . . . . | ·062 |
| „ „ | flint glass. . . . . | ·052 |
| „ „ | Canada balsam . . . | ·045 |
| „ „ | diamond . . . . . | ·038 |
| „ „ | crown glass . . . . | ·034 |
| „ „ | alcohol . . . . . | ·029 |
| „ „ | rock crystal . . . . | ·026 |
| „ „ | fluor spar. . . . . | ·022 |

In an achromatic lens, formed of two single lenses in contact, the focal lengths of the single lenses are proportional to the dispersive powers of the respective glasses.

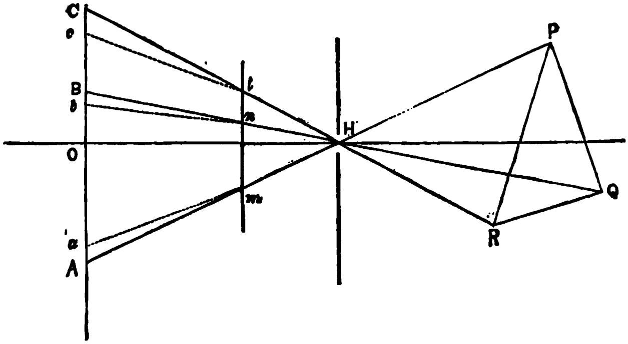
**Dispersion, Irrationality of.** "By measuring the spectra in Fraunhofer's manner, it is found that the distance between any, the same two fixed lines of the spectrum has not a constant ratio to the distance between the extreme fixed lines where different media are used. This circumstance is called the 'Irrationality of Dispersion.'

"If refracting media had no irrationality, then, in providing a combination such that two given lines should not be separated, we should at the same time unite lights of all species. But, since the colours are disproportionately dispersed in different media, the other lines will, in such a case, be very nearly, but not exactly united." (Griffin's "Optics," pages 95 and 100.)

**Dissolving Views.** The transparent slides for dissolving views may be printed by photography. *See* "Transparencies" and "Magic Lantern."

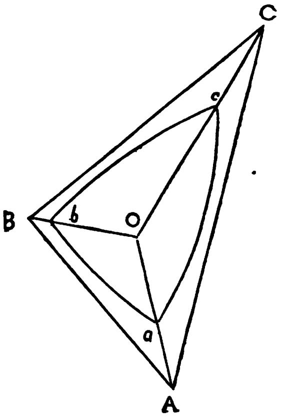
**Distortion.** When the image formed by a lens on the focussing screen of a camera obscura does not satisfy the conditions imposed by the rules of perspective, it is said to be distorted.

Distortion of the image in the camera obscura is in general produced by the excentrical incidence of the oblique pencils. Its effect is to render all straight lines which do not pass through the centre of the picture curvilinear, and also to exaggerate the dimensions of certain objects in the picture, with respect to others, in a way which is opposed to the principles of true perspective. We shall explain how distortion arises when a large view lens is used with a diaphragm in front, as this arrangement offers an illustration of the evil in a very marked degree.



Suppose P Q R to be a triangle placed in front of a large view lens *l m*, having a diaphragm in front at H. First, let the lens be removed, and the size of the aperture at H reduced indefinitely. Then, images A, B, C, of the points P, Q, R, will be formed on the focussing screen by producing the lines P H, Q H, R H, until they cut it, and the triangle A B C on the focussing screen will be a correct perspective view of P Q R.

Now introduce the lens *l m*.



The small oblique excentrical pencil P H, incident at *m*, is bent out of its course by refraction through the margin of the lens, and comes to a focus at *a*. Similarly, the pencils from Q, R, have their foci at *b*, *c*. The image given by the lens is, therefore, the triangle *a b c*. This triangle is smaller than A B C; but, if the distances A *a*, B *b*, C*c*, are proportional to O A, O B, O C, the two triangles will be similar figures, and there will be no distortion. But it happens that the decrements A *a*, B *b*, C *c*, are *not* proportional to the radial lines OA, O B, O C, but increase more rapidly than these do. There is, therefore, distortion of the image, as shown in the figure.

DOUBLE IODIDE. By this term is meant "double iodide of silver and potassium,"—that is, a solution of iodide of silver in iodide of potassium; a *very strong* solution of iodide of potassium being capable of dissolving a *small* quantity of iodide of silver.

Double iodide is used in the calotype process, and is made thus:—

Dissolve in one measure 20 grains of nitrate of silver in about an ounce of distilled water (the quantity is not material), and in another measure dissolve 20 grains of iodide of potassium in about the same quantity of distilled water. Mix the solutions. The mixture immediately becomes yellow and turbid, and a yellow precipitate, which is iodide of silver, soon subsides. Pour off as much as possible of the liquid (which contains nitrate of potass), then add an ounce of distilled water to the precipitate, and as much iodide of potassium in crystals as will completely dissolve it, and render the solution colourless, *but no more*. The quantity required will be about 200 grains. Shake well after each addition of fresh crystals, and wait till they are dissolved before adding more, proceeding cautiously towards the last.

Double iodide is rendered turbid by the addition of water, but the turbidity may be removed by adding crystals of iodide of potassium.

DOUBLE REFRACTION. *See* "Light."

**Dragon's Blood.** A deep red resin brought from the East Indies. It is soluble in ether and alcohol, and also in alkaline solutions. It combines with metallic oxides, forming red compounds. The alcoholic solution is much used in lacquers, to which it imparts a red colour.

**Dry Collodion Process.** If a collodion plate, excited in the usual way, is allowed to get dry, without having previously washed off the free nitrate of silver, the yellow layer of iodide of silver disappears, and the film becomes transparent and insensitive. This arises from the fact that iodide of silver is soluble in a *concentrated* solution of nitrate of silver; so that, as the moisture evaporates from the film, the free nitrate becomes concentrated, and dissolves the iodide of silver, forming a double salt, which has been called iodo-nitrate of silver. In order, therefore, to use the collodion film in a dry state, it is found necessary in the first place to remove the greater part of the free nitrate of silver by washing; and another condition is, that the collodion shall adhere tightly to the plate when dry, and not contract, or form blisters when the solutions are applied to it a second time, after having been once dried.

All these conditions are fulfilled by the simple and excellent process of Dr. Hill Norris, of Birmingham, which is as follows:—

The plate is collodionized and excited in the usual way, and then washed with distilled water, until as much as possible of the free nitrate of silver is removed. This done, a solution of gelatine is poured over it, made by dissolving 80 grains of gelatine in 20 ounces of distilled water at the boiling point, filtering while hot, and then boiling down to half the quantity, stirring well with a glass rod, and, when cooled down a little, adding 1½ ounces of alcohol. Before applying this gelatine preservative solution, it should be heated by immersing the bottle containing it in hot water, and poured over the plate hot. The plate is then left to dry spontaneously, or it may be dried by artificial heat.

Plates so prepared may be kept sensitive for many months; Dr. Norris says indefinitely.

The exposure in the camera must be much longer than in the wet process; as long, perhaps, as for waxed-paper.

The development is accomplished thus:—The plate is first immersed for five minutes in a dish of distilled water; then the usual mixture of pyrogallic and acetic acid is made in a chemically clean measure, and a few drops of nitrate of silver added to it; this is poured over the plate, and the picture developed in precisely the same way and as quickly as in the wet process.

The picture is fixed either with hyposulphite of soda, or cyanide of potassium, in the usual way, and varnished like an ordinary negative.

When the chemicals are in good order, this process is as certain, and yields as good results, as wet collodion.

Another excellent dry collodion process, due to Mr. Fothergill, is as follows:—

The excited plate, after removal from the nitrate bath, is washed *once* with distilled water; then albumen is poured over it; it is then washed again. The remaining treatment is the same as Dr. Hill Norris's. The rationale of this process appears to be that the albumen forms, with the free nitrate in the film, a minute quantity of albuminate of silver. These plates do not keep so well as Dr. Norris's, but are more sensitive. The process was tried by him and abandoned, long before Mr. Fothergill brought it forward.

In all dry collodion processes it is important to use a powdery non-contractile collodion, made with acids at a temperature not lower than 150°, and of the minimum strength that is consistent with a structureless film.

**Drying Oils.** These oils are distinguished from greasy or fatty oils, by their property of becoming oxidized when exposed in thin layers to the air, and forming a dry resinous varnish; an effect which is accelerated by dissolving in them a small quantity of oxide of lead. The principal drying oils are—poppyseed oil, linseed oil, and nut oil. Fatty oils which do not dry become rancid under similar circumstances. Palm oil is an instance of this property. *See* "Oils."

**Dutch Varnish.** Used for paper, parchment, &c. Mix, with the aid of heat:—

| | |
|---|---|
| Sandarach . . . . . | 120 parts |
| Mastic . . . . . . | 120 ,, |
| Venice turpentine . . . | 120 ,, |
| Amber . . . . . . | 30 ,, |
| Linseed oil . . . . | 250 ,, |
| Turpentine . . . . | 250 ,, |

**Dyeing.** The principles of dyeing and calico printing may be included shortly in those of photography, from the fact that certain chemicals are capable of becoming mordants by exposure to light. The object of dyeing is to produce a permanent combination between the material to be dyed and the colouring matter. This combination is effected by means of a mordant, which combines chemically with the stuff to be dyed, and at the same time with the colouring matter, forming, so to speak, a triple combination. Without the mordant, the colouring matter might of course be removed from the fabric by washing it in water, since it would offer a mere case of mixture, and not of chemical combination.

It is found that bichromate of potass has the property of becoming a mordant by exposure to light, and this property has already been taken advantage of by calico printers in Paris, to print designs upon textile fabrics by means of photography. If a piece of paper is rubbed over with a little indigo mixed with bichromate of potass, dried in the dark, and exposed under a negative, the parts acted on by light are permanently fixed, while from those not acted on, the colour may be removed by washing the paper in water.

Processes of this kind offer a new and important field of research, for the want of permanence of ordinary photographs printed with the salts of silver is a very serious evil.

The principal dyes are indigo, cochineal, madder, quercitron, logwood, annatto, lake, prussian blue, various salts of iron, copper, lead, chromium, cobalt, &c., and the principal mordants proto-chloride of tin, alum, sulphate of iron, &c.

**DYNACTINOMETER.** An instrument for measuring the intensity of actinic power, or for comparing the " quickness" of lenses. *See* " Hunt's Treatise on Photography."

**EARTHENWARE, GLAZE FOR.** As earthenware vessels are much used in photography, the mode of glazing them should not be disregarded, as some of the chemicals, (nitrate of silver, for instance,) act on the glaze.

The common white dishes are glazed with

| | |
|---|---|
| White lead . . . . . . . | 53 parts. |
| Cornish stone . . . . . | 16 „ |
| Ground flints . . . . . | 36 „ |
| Flint glass . . . . . . . | 4 „ |

Stone ware is glazed with a mixture similar to the above, but containing also red lead. The materials are pulverized, and then mixed into a paste with water; this is spread upon the vessel to be glazed, which is then submitted to the furnace, which vitrifies the glaze.

**EAU BROMÈE.** Bromine water, formerly used in the daguerreotype process, but now superseded by bromide of lime, because in hot weather the vapour from the bromine water condenses on the cold plate, and interferes with the production of a good impression.

EFFLORESCENCE. When a crystallized salt parts with its water of crystallization by exposure to dry air, and crumbles into a powder, it is said to "effloresce." Sulphate of soda is an instance of this property.

EGGS. As the albumen obtained from eggs is much used in photography, it becomes important to know something about eggs.

The albumen contained in eggs has been described in the article "ALBUMEN." The yelk of the hen's egg contains about 30 per cent. of oil, in which phosphorus is present. New-laid eggs are heavier than water, but gradually become lighter by the evaporation of water through the shell. Of an egg which weighs 1000 grains, 106·9 parts constitute the shell, 604·2 the white, and 288·9 the yelk.

ELECTRICAL IMAGES. *See* "Moser's Experiments."

ELECTRO-CHEMICAL ACTION OF THE SOLAR RAYS. Mr. Robert Hunt has, from some experiments described at pages 291, and following, of his "Researches on Light," arrived at the following conclusions:—

1st.—"That electro-metallic precipitation is prevented by the sun's rays."

2nd.—"That light is not the retarding agent, but the exercise of electrical force is negatived by the direct influence of actinism."

These conclusions must be received with caution, as being purely hypothetical, and very probably erroneous.

ELEMENTS. The elements, or elementary bodies, are such as have hitherto resisted all attempts to reduce them into simpler forms of matter. They are fifty-five in number, and will be found arranged in alphabetical order in the Table at the end of the work.

ELEMI. This is a species of resin much used in varnishes. There are several varieties of it. The principal are obtained from the *Canarium balsamiferum* of Ceylon, and the *Icica icicariba* of the Brazils. Elemi is at first soft and viscid, but becomes hard and brittle by cold and age. It is yellow, translucent, and of a peculiar odour resembling fennel. It contains 60 parts per cent. of an acid resin soluble in cold alcohol, and 20 parts of an indifferent crystallizable resin soluble in hot alcohol.

**Elliotype Process.** A process patented by Mr. Robinson Elliot, of South Shields, for enabling artists to obtain an indefinite number of photographic copies of their works.

A painting is made upon glass in a body colour, more or less transparent according to its density, and the thickness with which it is applied. The painting is then treated as a negative, and positives are printed from it in the usual way.

**Emery.** A dark coloured mineral, found in abundance near Cape Emeri, in the island of Naxos. It occurs also in the Channel Islands, Poland, Sweden, Persia, &c. According to Mr. Tennant's analysis, it is composed of alumina 80 parts, silica 3 parts, iron 4 parts. When reduced to powder emery varies in colour from dark grey to black. Examined under the microscope the powder is seen to be composed of two crystals, viz., corundum, and oxide of iron. This powder is so hard as to scratch quartz and many precious stones. It is used in the arts for grinding, polishing, and scouring articles of metal, glass, &c.

**Emery Paper; Emery Cloth.** Emery powder may be spread upon paper or cloth by first applying a coating of thin glue, and then dusting the powder over it from a sieve. There are six degrees of coarseness. To use emery paper, it should be wrapped round a stick and a little oil applied, which makes it cut better. Emery cake is made by mixing emery powder with bees-wax.

Razor-strop paper is made by mixing the finest emery powder and a little finely powdered glass with paper pulp, and making it into sheets in the ordinary way. This should be glued to a piece of wood, and a little oil applied occasionally. The emery and glass constitute more than half the weight of the paper.

**Empyreuma.** The offensive smell produced by the combustion of organic matters, chiefly vegetable, in closed vessels.

**Enamelled Photographs.** In the "Comptes Rendus" of June 11, 1855, various methods of producing enamelled photographs are described by M. A. Lafon de Camarsac. The following translation of this article is extracted from the Journal of the Photographic Society for September 21st, 1855 :—

"I select for grounds either metals or substances used for pottery;

I use vitrifiable compounds for tracing the image on them; and I operate both on the images obtained by the use of metallic salts and those furnished by the resins.

"With pictures produced by the aid of collodion, albumen, gelatine, and by the ordinary processes of the salts of silver, I develop the image by nitrate of silver until the half tints are overdone and obscured, and the deep shades are covered with a thick deposit presenting the appearance of a bas-relief. The proof is then placed in an enameller's muffle; the organic matters vanish under the action of a suitable temperature. The fire cleans the image and restores all its delicacy.

"I operate on white grounds, or black, or coloured grounds. On tinted porcelain, coloured glass, or on brown or black enamel, the whites of the image are formed by the deposit of reduced metal, which acquires great brilliancy in the furnace. On white porcelain, or enamel, or on transparent glass, the blacks of the image will be formed by the metallic deposit, which I then treat with solutions of salts of tin, salts of gold, or salts of chromium. In the latter case I obtain various colours, very vigorous when removed from the muffle, presenting a peculiar semi-metallic brilliancy. A very thin layer of an appropriate and very fusible flux fixes the image on the ground, as in the case of applying gold or silver to porcelain. On enamel, the fusion of the matrix itself fulfils the same office.

"With regard to images obtained by the action of light upon salts of chromium,—as soon as the image is cleaned by distilled water I expose it in a muffle to temperature which destroys the gelatine; the metallic deposit remains alone upon the ground. Salts of silver and of lead laid on this give yellow tints after baking; salts of tin and of gold produce violets and purples. These colours are developed under a layer of flux which here covers the metallic deposit. The image presents the appearance of a painting on porcelain.

"The pictures furnished by resins are treated differently. I compound a coating capable of receiving application of a negative, and of being easily rendered sticky after the exposure to light. Solution of bitumen of Judæa in essence of turpentine, with the addition of resin, fulfils this requirement. The exposure to light being finished and the solvent having performed its office, I proceed to the substitution of ceramic colours for this varnish, which must be destroyed by the fire. Metallic oxides and their fluxes, ground very fine and dried, are deposited on the surface of the image, while a gentle and graduated heat restores to the coating the adhesive property it had lost in drying. These enamel powders, carried over the entire surface of the picture, follow with great delicacy all the inequalities of the subject, which they partially penetrate, and translate faithfully all its depths and delicacies. The piece is then ready for the fire; the organic matters are destroyed, and the image, formed of indestructible substances, remains fixed by vitrification.

"One of the remarkable characters of these images is the aspect of under-enamel (*sous-émail*) which they present, which cannot be furnished in the same degree of perfection by any other kind of painting.

"The heliographic image thus treated may receive any kind of colouring: it may be transformed into gold or silver as well as into blue or purple; it may even be burnt into porcelain with the furnace colours.

"Observing that, in the same image, the light, in tracing the bright parts, left a faithful image of the shadows, and that the entire negative *cliché* might be transformed into a positive *cliché*,—I was led to combine two opposite and successive impressions of the same image. By taking from one of these impressions all the light tints and from the other all the dark ones, I obtained the image of the lights (defined) by the shades, and of the shades (defined) by the lights, with the infinite variety of tints resulting from the combination."

**ENCAUSTIC PAINTING.** This method of painting, which is of great antiquity, consists in using wax with the colours, in order to give them a gloss, and preserve them from injury. Proceed thus:—

Melt together equal quantities of white wax and powdered mastic, stirring well. Pour the melted mixture into cold water, which hardens it; then pound it in a mortar. This powder is to be mixed with strong gum arabic, and added to the common water-colours, which are then to be used at once in the ordinary way, diluted with water as occasion may require, and applied with a brush. The pale colours require least, and the dark ones most of the powder to be added to them. The picture must be very highly and carefully finished. It is then to be varnished with a mixture of one part white wax, and two parts turpentine, applied hot, and the superfluity allowed to run off.

The wood, or cloth, or paper, to be painted upon must first be waxed.

**ENGRAVING, HELIOGRAPHIC.** The processes of heliographic engraving have not yet been brought to sufficient perfection to be worthy of more than a few brief remarks in this place.

M. Nicéphore Niépce availed himself of the property possessed by bitumen of Judæa, of being rendered insoluble in the usual menstrua by the joint action of light and oxygen. A metal plate was coated, in the dark, with a solution of bitumen in a solvent, dried, and exposed to light under an engraving, or in the camera. It was then washed with a solvent, which removed the bitumen where light had not acted, and allowed it to remain where light and oxygen had rendered it insoluble. The bare metal thus exposed was then etched with an acid, and an engraving produced.

This process was followed up by M. Niépce de St. Victor, and some improvements made in it, which will be found described at different times in his communications to the French Academy of Sciences.

Mr. Fox Talbot, a few years ago, obtained some little success with a rather different, and, we imagine, a better process. He coated a steel plate with a mixture of gelatine and bichromate of potass, and exposed it to light under a negative. Where the light acted on this mixture, it reduced the salt of chromium, and caused it to combine with the gelatine, thereby producing a compound which was insoluble in water. The plate was then washed with water, which removed the unaltered gelatine only. A picture was in this way produced upon the plate, which was etched by a solution of bichloride of platinum, which attacked only those parts where the metal was not protected by the gelatinous compound.

MM. Salmon and Garnier have suggested a process of heliographic engraving different from either of the preceding, and which appears very ingenious.

"If a polished plate of brass, previously submitted to the action of iodine vapour, is exposed to diffused light, and then rubbed with wadding, charged with globules of mercury, the following phenomena will be observed—the plate will not be amalgamated, the mercury refusing to attach itself wherever the iodine has been influenced by light. If, instead of proceeding thus, the plate is covered in places with an opaque body, and we then try to amalgamate it as before, it will be observed that the mercury takes perfectly on the parts where light has not acted, while it refuses to adhere in other places. This property, discovered by MM. Salmon and Garnier, indicates the possibility of reproducing photographic images upon a plate of brass. A negative on glass, or paper, is applied to the iodized brass plate, and left in contact from ten minutes to two hours in diffused light. On mercurializing the plate, the mercury is seen to adhere to those parts which correspond to the blacks of the negative, leaving the other parts intact. If an ink-roller is then passed over, the untouched parts take the ink, while the mercurialized parts do not, so that the picture is black upon a white ground.

"An etching may then be produced by first dissolving out the mercury by means of a solution of nitrate of silver acidified with nitric acid, and then biting in the plate still deeper by acid alone. If, on the other hand, an engraving is wanted for printing in a lithographic press, the plate is immersed for a few minutes in a galvanic bath charged with chloride of iron, so as to deposit a thin layer of metallic iron in the places previously occupied by the mercury, and where the brass is now bare, namely, on the lines of the drawing. The utility of this deposit of iron will soon be perceived. The brass plate being removed from the bath, the greasy ink is dissolved off with spirits of turpentine. The entire plate is then exposed again to the vapour of iodine, and rubbed with wadding bearing globules of mercury; whence it results that the plate, as before, acquires a white colour, from the amalgam of mercury; but as this metal does not amalgamate with iron (for mercury is preserved in iron vessels), a mere gentle rubbing of the plate removes it from the places covered with iron, that is to say, from the drawing itself; so that after the second operation the drawing has the lines covered by a thin layer of iron, while all the rest of the brass plate is coated with mercury.

"Things being in this state, the ink roller is passed over the plate; only the drawing itself takes the ink, while those parts coated with mercury repel it. This is just what was required. As many impressions as desired may now be printed, only taking the precaution to rub the plate afresh with mercury after a certain number of impressions have been thrown off. If it be wished indeed, the two last operations might be omitted: it would suffice to wet with water the plate once inked with greasy ink, as done by the lithographic printers; under these circumstances the parts free from the drawing would be isolated by water, which would prevent the greasy ink from touching them.

"Supposing now that instead of a plate to be printed in a lithographic press, it is desired to have one that may be printed with letter press, the following will be the mode of procedure:—Taking the plate at the moment when it is about to be immersed in the galvanic bath, a preparation of gold should be substituted for the salt of iron, and a thin layer allowed to deposit over the drawing (it will take the gold because it resists the action of the acids better); the plate is then inked and eaten away all round the lines, which will be preserved by the gold, the surrounding copper only being attacked, so that the drawing itself will be found in relief."

**ENGRAVING PHOTOGRAPHS UPON GLASS AND PORCELAIN.** A process of engraving photographs upon glass and porcelain was described by Mr. Thomas Sims, at a meeting of the Photographic Society, on January 1st, 1857. The following is the account given by him of this process:—

"Wishing to offer as much information as possible, without occupying too much space, I think I cannot do better than give the process of engraving photographs on glass, by means of hydro-fluoric acid gas, in the form of notes, which have been penned at various times, generally after making the experiments. Previous to this, however, it is necessary to give a general idea as to the mode by which I have taken the kind of photograph most suitable for the purpose. First, then, the collodion I use is *thin;* it has as much alcohol as it will bear, adding ether only when it is too gelatinous, iodized with iodide of silver dissolved in an excess of iodide of potassium. The glass here is a desideratum, as it is not only necessary to obtain it free from striæ and specks, but its component parts will, I believe, occupy the attention of photographers in time to come as much as paper has done for calotype. I have given crown, sheet, and several kinds of plate-glass very fair trials, and as yet I find none to yield so readily to the action of the hydro-fluoric acid gas as British patent plate.

"Some idea of the care I have taken to arrive at this conclusion may be perceived, when I state the manner in which I tested the quality. I have cut 9-inch plates of various kinds into four or six squares, putting each lot carefully apart; I have then taken one of each kind and marked it; collodionized and developed each with the same material, and photographed from the same model, such as a chalk bust or engraving, and have applied the hydro-fluoric acid in the same manner to each, and this two or three separate times, and in every case the patent plate showed itself to be most easily acted upon. Previous to putting on the collodion, and in order to cleanse the plate, I wash it in sulphuric acid and water.

"*Bath.*—30 grains of silver to the ounce of water, made in the usual way.

"The time in the camera is of consequence: it must be *timed* to a nicety, and developed well. (*See* Notes.)

"The developing solution is made with different samples of proto-sulphate of iron, ¼ pound of three or four samples, put together in rather a wide-mouthed bottle, and the crystals covered with distilled water, to which are added 2 drachms of acetic acid.

"When a developing solution, fit for use, is required, take 1½ ounce of this saturated solution and put to it 6 ounces of distilled water and 2 drachms of acetic acid. If this does not flow evenly over, add a drachm of alcohol; but if it can be done without it is better, as the alcohol is liable to produce grey pictures.

"I invariably fix with hyposulphite of soda; and too much care cannot be taken to get out the iodide of silver (and the same may be said of the hyposulphite of soda), with abundance of water and a wash or two with ammonia and water, and this, again, washed away with water.

"The plate must be dried with as much care as a daguerreotype and in the same manner, from the top downwards, evenly and regularly: the water must not concentrate itself upon any particular part, so as to dry in patches; for though the impression may pass through the burning process without showing the stain, it certainly will not stand the test of the hydro-fluoric acid gas, for the stains themselves will be engraved.

"It will be found that if the most minute particle of the iodide or hypo remains in the impression after washing, it will turn *black* quickly while *burning;* and if heat be long applied the impression will evaporate altogether, and this at not a very high temperature. This is a fact that has so many times come under my notice, often to my sorrow, that I have been led to conclude, reasoning from analogy, that the hypo must be the great enemy to the durability of paper photographs; for if a collodion film, which we have so much more power over in the way of cleansing, will yet, after all the washing, retain sufficient quantity of hypo-sulphite to be the destruction of the photograph, how much more is paper likely to do so!

"*Burning the Photograph.*—The only requisites necessary for this purpose are, *boxes* of sheet *iron* or *tin* of various sizes, and a *stove,* the top of which easily becomes slightly incandescent when the fire is lighted in it. The new boxes must be burnt to get rid of any grease in the iron ones, and of the tin and grease in the tin ones. They must be made a quarter of an inch larger than the size of the plate to be burnt in them; and they must also be rounded slightly at the bottom. If the first precaution be not taken, the box on cooling will contract and crack the glass. The reason for having the box a little rounded at the bottom is, to allow the operator to place the impression face downwards, which will enable him to stove the picture without having a cover on the box (provided the room be free from cold draughts), and to see how the process goes on; this may be easily done by holding the box with pincers in such a position as to get the reflected ray to the eye from the back of the impression; for, as the silver becomes reduced it assumes a mirror-like appearance.

"When speaking of the reduction of silver, it is associated in most minds with the idea of great heat, when the reduction is said to be by heat; this is liable to mislead: a great heat is not only unnecessary but objectionable; a dull red heat is the most required, for a low heat and a longer time does the work more effectually. (*See* Notes.)

"That the silver does become so reduced is very curious; it shows the metallic deposit to be in a peculiar state, and I imagine that the contraction of the film must take a mechanical part in the operation.

"If the operator allows the burning process to go on slowly, (say half-an-hour or more, as it varies with different impressions,) he cannot fail in this part of the process.

"When sufficiently burned, push the box containing the picture to a cool part of the stove, and, when cold enough to be taken hold of by the hand, the plate may be removed, and placed in a plate-box.

"It is better to engrave the picture as quickly as possible, or a film of oxide will soon damage it if not used.

"*Materials and Apparatus for the application of Hydro-fluoric Acid Gas*:—

"Fluor spar,
"Common sulphuric acid,
"A leaden pan and cover.

"Grind the fluor spar into fine powder, and put ½ ounce into the leaden pan, upon which pour 2 ounces of common sulphuric acid, and stir with a leaden rod. The size of a pan for a picture 3¼ × 2½ inches, should be 4 × 3 inches in width and breadth, and 4 inches in depth.

"The frames holding the plates over the vapour should be waxed or varnished, otherwise the wood absorbs the vapour; and it acts upon the edges of the plate before it receives the vapour from the pan, which should be placed upon a stand high enough to admit a spirit-lamp underneath. The stand holding the pan of hydro-fluoric acid should be placed upon the hob of a kitchen range, when there is a fire and the draught generally good, as this will carry away the fumes, which are suffocating unless the operator is fortunate enough to have a laboratory with all the requisites.

"If an ounce or so of water be used with the sulphuric acid, in the pan with the fluor spar, the spirit-lamp will not be much required; but the action is so rapid, that I prefer adding water some time previously, and letting the mixture become cool before putting in the fluor spar. Using the spirit-lamp, and not adding water gives the operator most control, and is the method I have adopted; but, in one or two cases, when water was added to raise the temperature, there was so much energy as to eat half through the glass. But this plan might really prove the best, provided it could be so modified as to be a little more manageable.

"When the hydro-fluoric acid is made to act upon the plate, it permeates the transparent coat first, except in the false action (mentioned in the notes); and in proportion as the silver, forming the opaque parts of the picture, increases in density from the half-tone to the high light, so is the time the acid takes to act; the high lights being the most opaque, resist the attack longest. When this part yields to the action of the acid, the whole of the picture is loosened from the surface of the glass, and any further action of the hydro-fluoric gas tends only to destroy the engraving which has been made, so that a few seconds will form an engraving, and a few seconds more, if the action be continued, will entirely destroy it, by eating too far into the body of the glass. It will thus be seen how great a nicety is the timing of the plate over the hydro-fluoric gas; it varies according to the nature of the glass, and the strength of the impression and of the gas, the latter being regulated by the size of the flame of the spirit-lamp, so that, like the timing of a picture in the camera, it would be difficult to state any time nearer than from five seconds to five minutes.

"The best plan is to take the plate up after about ten seconds, and if the picture has a uniform grey appearance by transmitted light, and a prismatic appearance by reflected light, there is every reason to suppose it will bear the action no longer. It is now to be washed off with clean cold water; but should the plate not be sufficiently cool for this, use warm water, and wipe dry. The engraving will be distinctly seen, and if strong will be easily felt; but if only a surface impression, it will be necessary to hold the glass in the same position as you would a daguerreotype, that the picture may be seen.

"It is evident that this paper, so far, applies to direct camera pictures: the lights of the picture being formed by the metallic deposit, the process of engraving being founded on the well-known resistance of silver, as well as other metals, to the action of hydro-fluoric acid on the one part, and the affinity which that acid has for glass on the other. If, therefore, the law holds good, the transparent parts of the proof will be bitten out, and the lights of the picture will be untouched, or nearly so. This is the kind of proof required to produce a plastic cast in relief, from which a plate for the press may be obtained by the electrotype process.

"To apply this process to *porcelain*, upon which material a direct picture is wanted as a permanent article, the process is the same, but the requirements differ.

" Some idea of the plan may be obtained when I state the necessity which brought it about; it was the desire to burn-in a photograph on *enamel* or porcelain: but a positive collodion picture will *not* sink into hard enamel; it will burn away before the enamel obtains heat enough to become soft. It will sink into soft enamel. The result, however, is so like a daguerreotype that I did not think it worth the trouble of continuing the work.

" When a collodion photograph is taken from a negative on white porcelain, the metallic deposit forms the dark part of the picture, and the white surface of the porcelain the whites of the picture.

" It is impossible to obtain good collodion pictures on unglazed porcelain, and the photograph will not stand the heat, as before mentioned, which is required to sink-in the impression, so that, to make the picture pass through the kiln, it is necessary to go over the photograph with enamel colours.

" On engraving this kind of picture on porcelain, I have found, especially with Mr. Minton's beautiful white tiles, that when the acid had acted too much, the picture still retained its hold of the porcelain and did not wash off as it does after the same action on glass; and when it was dried, all the glaze was found to be eaten off, but still the lines of the photograph were fixed as fast as ever. This is worthy the attention of persons who are anxious to apply photography to porcelain.

" The point of interest, however, for the photographer is the following:—If the porcelain is acted upon properly, those parts under the metallic lines are protected from the action of the acid, while the other parts are acted upon, so that the picture, after being engraved, is formed by the dull surface of the unglazed porcelain on the one part, and the brightness of the glazed on the other part. This is sufficient to convince me, that if we had white tiles 'flashed,' as it is technically termed, with a dark vitrifiable colour, we should be able to obtain an engraving with hydro-fluoric acid, *a white picture on a dark ground*, the acid eating out the bare parts of the proof, while those protected by the metallic deposit would retain the surface colour.

## NOTES.

"1. This acid acts most uniformly when there is a large proportion of sulphuric acid covering the bottom of the pan.

" There seems a very strong analogy between the working of this gas and the obtaining a deep sensitive coat, with the iodine on the daguerreotype plate.

"2. Whenever the hydro-fluoric acid acts through the silver, the impression is only on the surface, and is analogous to a weak collodion positive (if the impression engraved is a direct positive) and in appearance is very similar to a weak daguerreotype: as an *engraving* it is worthless. In the other case, when the operation is successful, and the silver has been so reduced as to resist the action of the hydro-fluoric acid the picture appears in the form of a negative on the glass; everything which, previous to engraving, was white will now appear the reverse, and when seen in a proper light, the picture has much the effect of an etching on steel; and when a hard substance, such as a needle or pin, be passed over it, the lines may be sensibly felt.

"3. The lines of demarcation, which can now be drawn between these very different results, are at present ill-defined, but are accumulating so fast as to promise that we shall be able to work with as much certainty as in iodizing a daguerreotype plate.

"4. The characteristics of an impression likely to turn out a superficial engraving are these:—

"A feeble and grey impression.

"A solarized impression.

"An undeveloped impression.

"If the impression be burnt too suddenly or too much, the result is the same. The reason why an overburned picture is likely to be affected by the hydro-fluoric acid through the silver, or not engraved at all, is probably because the film of collodion becomes carbonized; the silver also, under these circumstances, becomes granular and porous, and will rub off with a brush; the film of carbon will therefore resist the action of the acid as much or more than the granular silver.

"5. When the opaque parts of the impression are firm and solid, and the blacks rich and transparent, without a stain or mottle from the effects of impurities, either left by the chemicals used, or from the want of cleansing in the plate, the operator may depend upon a legitimate engraving, the only question being the *time* of exposure to the action of the hydro-fluoric acid gas; and in this part of the process nothing but experience will avail, as it depends upon a number of secondary conditions, which the novelty of the work has made impossible hitherto to reduce to rule.

"6. When the effect of the fluoric acid seemed very sudden, it immediately reminded me of the early days of daguerreotyping, when pure and undiluted bromide and chlorine was attempted, and I added three or four times more common sulphuric acid than was necessary for the evolution of the fluoric acid.

"7. The first portion of hydro-fluoric acid which rises in vapour is seldom or never of any good in the way of engraving; it destroys the picture without showing any lines of drawing; the same happens if the mixture is used too long; the latter may be easily accounted for, the former not so. Dr. Ure, in his 'Dictionary of Chemistry,' suggests it to be silicated fluoric acid, supposing the fluor spar experimented with might contain a portion of silica. This is also a sufficient reason why the most paltry experiment should not be conducted with glass vessels; glass covers should *not* be used to the leaden pan, for the same reason.

"8. If the proof becomes oxidized by lying about exposed to the air, before or after *burning*, it will not resist the action of the fluoric acid.

"9. If, in *burning*, the plate assumes a dark and charred appearance, it *never* becomes white again; but will be completely destroyed by further burning, and is occasioned by some salts which should have been washed out.

"10. The difficulty of obtaining a strong metallic deposit on the lines of the drawing, without getting the transparent parts of the picture grey, might suggest itself as a great objection. In answer to this, I have found it quite possible to augment these lines to a great extent, provided the impression is perfect, by the use of bichloride of mercury and ammonia; chloride of gold to precipitate it; another weak wash of bichloride of mercury; and this acted upon by a weak solution of iodide of potassium and common water, is used after each application to keep the precipitate from the transparent parts of the film. After which a 30-grain solution of nitrate of silver is poured evenly over the plate and washed with water; the plate is then exposed to the *light*, when the metallic parts turn intensely black, and the lines become so *raised* that it will itself yield a plate by the electrotyping process."

Equivalent. On referring to the table of Elementary Substances, the reader will observe that against every substance a certain number is placed, called its "Equivalent," or sometimes its "atomic weight." For instance; silver has the equivalent 108, iodine 126, carbon 6, sulphur 16, and so on. The meaning of these numbers we will endeavour to explain.

It is found by experiment that substances combine with one another only in certain definite proportions by weight; and, reasoning on this fact, it has been supposed that matter is not indefinitely divisible, but that bodies are composed of atoms incapable of being divided into smaller fragments, and therefore called "ultimate atoms," these ultimate atoms being of different weight in different bodies. On this hypothesis, the equivalent of any elementary body is the weight of an ultimate atom of that body, the unit of weight being of course indefinitely small, but the same for all substances; and the equivalent of a compound body is the total weight of all the single atoms composing the compound atom. If, then, we say that the equivalent of silver is 108, we mean that an ultimate atom of silver weighs 108 units of weight; and since in the same scale the equivalent of hydrogen is 1, it appears that the unit of weight in that scale is the weight of an ultimate atom of hydrogen.

But this explanation of the meaning of the table of equivalents involves a hypothesis which, however reasonable it may appear, may nevertheless be false and is after all *but* a hypothesis. If then we reject the explanation given according to this hypothesis, and confine ourselves to the facts of the case, the table of equivalents becomes merely a table of the proportions by weight in which different bodies are found to combine.

In order to show the utility of this table, take the following examples:—

1st. In an ounce (480 grains) of chloride of silver, how many grains of silver and how many of chlorine are there?

The equivalent of silver is 108, of chlorine 36; the equivalent of chloride of silver is therefore 144. If, then, we multiply 480 by 108, and divide by 144, we get the number of grains of silver in the ounce of chloride, viz. 360; and if we multiply 480 by 36, and divide by 144, we get the number of grains of chlorine, viz. 120. There are, therefore, in an ounce of chloride of silver 360 grains of silver, and 120 grains of chlorine.

2nd. Required to know how much iodide of potassium will exactly decompose one ounce (480 grains) of nitrate of silver, neither of these salts containing any water of crystallization.

Nitric acid is composed of 1 part nitrogen and 5 parts oxygen by weight. The equivalent of nitrogen is 14, of oxygen 8. The equivalent of nitric acid is therefore 54, and of oxide of silver 108 + 8, viz. 116. The equivalent of nitrate of silver is therefore 116 + 54, viz. 170.

Iodide of potassium is a salt containing no water of crystallization. The equivalent of iodine is 126, and of potassium 40; and therefore of iodide of potassium 166.

In the decomposition of nitrate of silver by iodide of potassium, there are formed nitrate of potass and iodide of silver. If, then, we multiply 480 by 170, and divide by 166, we obtain the exact number of grains of iodide of potassium necessary to effect the decomposition, viz. 491$\frac{47}{83}$.

A Table of Equivalents of the simple substances will be found at the end of the work.

**Equivalent Focus.** *See* "Focus."

**Ether.** Oxide of ethyle. $C_4 H_5 O = Ae. O.$

Alcohol is supposed to be a hydrate of ether, two volumes of alcoholic vapour being composed of one volume of aqueous vapour, and one of the vapour of ether. If, then, alcohol be decomposed, and the elements of water removed, the result is the production of ether. Such is the theory of etherification.

Ether, or as it is frequently called, "sulphuric ether," is an extremely volatile, colourless, combustible, fragrant liquid, obtained by distilling together alcohol and sulphuric acid. It is of great use in photography as a solvent of pyroxyline.

The manufacture of ether is an extremely dangerous operation, and should not be attempted by the amateur. The mode in which it may be made, either on a large or small scale, with the proper precautions, is as follows:—

A large flask contains the mixture of alcohol and sulphuric acid. It has a stopper with three holes in it: through one is inserted a thermometer tube, through another the pipe which leads to the condenser, and through the third a tube through which a fresh supply of alcohol is kept up. The flask is placed in a sand bath, and heat applied, which may be regulated as required.

In using the apparatus, a mixture of 8 parts by weight of concentrated sulphuric acid, and 5 parts of alcohol S.G. ·834, is put into the flask and heated till it boils and rises to a temperature of 300° Fahrenheit. Fresh alcohol is then introduced as required, and this temperature evenly maintained, the liquid in the flask being kept in rapid ebullition. The bulk of the liquid in the flask is in this way kept up for any length of time, and every drop of alcohol introduced is converted into ether and water, the mixed vapours of which go over together through the condenser into the receiver, where the ether floats upon the surface of the water. When the operation is properly conducted, the same quantity of sulphuric acid is sufficient for any amount of alcohol that may be added to it. The limits of the ether-producing temperature are between 260° and 310°: if the boiling point should fall below 260° by using too much alcohol or too weak acid, little else than unchanged alcohol distils over; and if, by using too much sulphuric acid, the boiling point rises above 320°, olefiant gas is generated, besides variable quantities of other impurities.

Ether will take up one-ninth part of its bulk of water, and will mix with alcohol in any proportion. In order to obtain pure ether, free from both alcohol and water, it is first mixed with about twice its volume of water, and well shaken; this separates the alcohol, which leaves the ether, and goes to the water. The ether, which floats on the water, is then carefully decanted, and a sufficient quantity of fresh-burned lime added to it: this abstracts the water. The mixture is then distilled with great care, the receiver being surrounded with ice and carefully stopped. The first third which distils over is pure ether.

The S.G. of pure ether at 60° Fahrenheit is ·724. It boils at 96° Fahrenheit, at the mean pressure of the atmosphere. It is neither acid nor alkaline, has a high refractive power in regard to light, and is a non-conductor of electricity. It is extremely volatile, and its vapour very dense and highly elastic. Ether burns without leaving a residue, and produces carbonic acid and water. It should be kept in well-stoppered bottles, as it turns acid by contact with air, from the production, first, of acetic ether, and subsequently, acetic acid.

Iodine and bromine are soluble in ether, and gradually react upon and decompose it, producing hydriodic and hydrobromic acids.

Ammoniacal gas and hydrochloric acid gas are readily absorbed by ether. Potassa and soda act feebly upon it, and give rise, among other products, to acetic and formic acids, which unite to the alkali. Many salts are soluble in ether, and especially the chlorides of gold, platinum, iron, and uranium.

The fixed and volatile oils, many of the resins, caoutchouc, various forms of extractive, the alkaloids, and some other vegetable principles, are more or less soluble in ether.

The chief use of ether in photography is to dissolve pyroxyline and form collodion.

By adding a variety of different acids to alcohol, and distilling the mixture, corresponding varieties of ether are produced. Hence we have nitrous ether, oxalic ether, hydrochloric ether, acetic ether, and so on. As none of these ethers are at present of any use in photography, it would be out of place to describe them in this work.

A table, indicating the quantity of alcohol contained in ether of variable specific gravity, will be found among the tables at the end.

**Ethyl.** $Ae. = C_4\,H_5$. Ether is the oxide of ethyl, $C_4\,H_5\,O$; and alcohol the hydrate of ether, $C_4\,H_5\,O,\,H\,O$. Ethyl was for some time a hypothetical substance, but a substance having the composition $C_4\,H_5$ has lately been obtained by Dr. Frankland, by exposing iodide of ethyl in sealed tubes to the action of metallic zinc, at 320°. On opening the tubes, and allowing the gas to pass into a freezing mixture kept at—9°, the ethyl condenses to a colourless liquid. Chlorine acts upon it in the light, but not in the dark.

No compound ethers have yet been produced from ethyl, and at present the ethyl theory must be considered as hypothetical.

**Exposure.** The exposure of a sensitive surface to light, either in the camera or pressure frame, is one of the most important features of every photographic process; and we shall endeavour to describe in this place the effects due both to *over* and *under* exposure in the principal processes, and as far as possible to account for them satisfactorily.

The simplest case is that of sun-printing on chloride paper. Here a sensitive surface consisting of chloride of silver, nitrate of silver, and organic matter is exposed to direct light until a visible image of the required strength is obtained. The effect of light on such a surface is to decompose it and produce a dark material composed of subchloride of silver, together with a compound of suboxide of silver and organic matter. When the image thus obtained, and which is of a purple brown tint, is put into the bath of hyposulphite of soda, in order to fix it by removing the unaltered chloride of silver, the purple subchloride in the image is also decomposed into chloride of silver and metallic silver, and the former dissolved out. The fixing bath therefore not only removes the superfluous chloride in the paper, but also enfeebles the dark tint of the shadows of the picture, by changing it from a deep purple to a red or brown. When sufficient allowance is not made for this change which occurs in fixing a print, it is of course "under-exposed" or "under-printed." When, on the other hand, the exposure is carried too far, the reduced organic compound of silver presents a metallic lustre, or bronzed appearance, and the details in the shadows are obliterated, and buried beneath a crust which is not easily removed in the fixing bath.

In printing by development on chloride paper, when the print is under-exposed, the details in the lights cannot be brought out until the development has been carried so far as either to stain the paper all over, or bury the details in the shadows. When the print is over-exposed, the details in the lights come out so rapidly in the gallic acid, and darken so quickly, that the development has to be stopped before the blacks have time to acquire sufficient depth and vigour. The picture is therefore red and feeble, and the lights and shades do not exhibit sufficient contrast.

It will be observed that in printing on chloride paper by direct light, the longer the exposure the darker the picture becomes, *up to a certain point*, and then the reduced material afterwards assumes a metallic appearance. So also in development printing on chloride paper, the longer the exposure and the longer the development the darker the blacks become, *up to a certain point*, and then, as in the other case, they assume a metallic appearance. By carrying the process too far, the same effect happens in both cases. And not only so, but this effect happens in every other photographic process with metallic salts. Excessive exposure produces an amount of reduction which defeats its object by exhibiting the metallic or solarized appearance in the case of a positive print, or, in the case of a negative, that metallic condition of the reduced salt which interferes with its property of becoming a centre of attraction for the matter which should accumulate upon it from the developer.

But in these remarks we are anticipating the cases of the Collodion and Daguerreotype processes, in which iodide of silver takes the place of chloride. In these cases a curious effect occurs through over-exposure, which has been called, we think improperly, the "reverse action of light." In the Collodion process the sensitiveness of the film is due to the presence of an excess of free nitrate of silver, which it is impossible to remove by any amount of washing with water, because it probably combines with the organic matter of the film. This free nitrate, existing in minute quantity in presence of iodide of silver, is decomposed by light with extraordinary rapidity, and when not over-exposed and rendered metallic, it furnishes the proper centres of attraction for the developing pyrogallo-nitrate. But if rendered metallic by over-exposure, it no longer acts in this way, and therefore no dark material is precipitated upon it from the developer. In order, therefore, to gain the greatest intensity in the image, there is a certain amount of exposure which must not be exceeded.

In the daguerreotype process over-exposure produces in the iodized surface an effect which is shown by the solarized part looking blue, or sometimes quite metallic. In an over-exposed collodion positive a very similar effect of blueness is produced, which shows the analogy existing between the processes.

It appears, therefore, that by over-exposure not only is more material reduced, but the reduction of the atoms which are first acted on by light is carried to such a stage, that they look metallic instead of black in positive prints, and in negatives cease to become fit centres of attraction for the production of a picture by a developing or intensifying process.

FADING. It is unfortunately by no means an uncommon thing for photographs to become altered by time, even when preserved with the utmost care. In the case of daguerreotypes, or collodion positives or negatives, or negatives upon paper, this misfortune is, however, comparatively rare; but in the case of paper positives which have been printed by direct exposure to light, and fixed and toned with hypo-baths, fading may unfortunately be said to be the rule, and permanence the exception.

Experience has sufficiently proved that the black material of a developed argentine photograph on glass or paper is permanent when the fixing agent (hyposulphite of soda or cyanide of potassium) is removed by copious and thorough washing in water many times renewed. The same may be said of the thin white metallic precipitate which forms the lights of a collodion positive. It is however necessary, in the case of a collodion positive or negative, to varnish the film, for if this be not done, the pyroxyline is liable to be decomposed, and give off an oxide of nitrogen which destroys the image.

The most serious case of fading is therefore that which occurs where the material of the image is a red compound of organic matter and a low oxide of silver, as in a sun-print, or a red developed print stopped in too early a stage of the development,—the picture being then fixed in a hypo-bath, containing sulphurating salts. Positives produced in this way may be considered certain to fade in from two or three months to as many years, no matter how carefully they may be preserved, or how thoroughly washed after their fixation. The faded appearance is produced by the dark brown tints of the shadows turning yellow.

The chemistry of fading is at present very obscure, but the phenomena may be produced at pleasure by immersing a fixed red sun-print in a weak bath of hydrosulphate of ammonia. The red tones first darken to a brown or purple brown, then to a purple black, and ultimately to a yellow, the entire series of changes only occupying a few minutes. If then the hypo-bath contains, as it always does, a sulphurating compound analogous to the sulphide of ammonium, and any of this should remain, as it probably must do, in the pores of the paper, it is easy to understand why the thin red material of the print becomes yellow by time.

As nothing certain has yet been proved with respect to the composition of this yellow substance, we will not offer any conjectures with respect to it.

When sel d'or is used to tone a print, it is more likely to be permanent, because the effect of this mode of toning is to substitute gold for silver in the material of the image. This is done most effectually by toning the print in a bath of sel d'or before fixing it in hypo. When chloride of gold is added to hyposulphite of soda in excess, and a toning and fixing bath made in this way to act together, the deposition of gold takes place simultaneously with the sulphuration of the silver, and the image is less permanent than in the former case.

But even metallic gold will not entirely resist the action of an alkaline sulphide, for this combines with it, and forms a double sulphide of gold and the alkali. This is probably why prints toned with gold have sometimes been known to change from a purple tint to reddish yellow, particularly in the finer details of the lights.

The liability of argentine photographs to fade when sulphur is present in the paper renders it therefore very desirable that a process of printing in carbon, or some permanent pigment, or dye, should be brought to sufficient perfection to be substituted for the present methods.

**Fahrenheit's Thermometer.** (Greek, θέρμη, heat, μετρον, a measure.) In this thermometer the freezing point of water, or temperature of melting snow, is marked + 32°, and the boiling point of water in a thin clean metallic vessel, at an atmospheric pressure of 30 inches, + 212°. The space, therefore, between the freezing and boiling points of water is divided into 180°. In the Centigrade Thermometer this space is divided into 100°, the freezing point being 0 and the boiling point 100°. There is a table at the end in which Fahrenheit's thermometer and the Centigrade are placed side by side, and the scales compared.

**Fermentation.** This is a peculiar metamorphosis brought about in solutions of certain organic substances, such as sugar, by the introduction of a decomposing azotized body, called a "ferment."

The particular case of fermentation with which the photographer is most concerned is that of the conversion of sugar into alcohol, which is called the "vinous fermentation." A solution of sugar in water is permanent, but if a putrescible animal substance, such as albumen, *in the proper stage of decay*, be added to it, at a proper temperature, the sugar is converted into alcohol, and carbonic acid given off. The formula by which this decomposition is represented is as follows:—$C_{12} H_{12} O_{12} = 2 (C_4 H_5 O + H O) + 4 C O_2$: *i. e.* grape sugar = 2 alcohol + 4 carbonic acid.

The most convenient ferment to employ is yeast, (*q. v.*,) in an active state. This sets up the action in the sugar, by which it is first converted into grape sugar, and then into alcohol and carbonic acid. The exact mode in which the ferment acts is not clearly understood.

When the fermentation is completed the liquid becomes clear, and contains the alcohol, which is obtained from it by distillation. The yeast which has been destroyed is converted into a grey amorphous substance, insoluble in water, scarcely azotized, and quite inert. The proper temperature at which fermentation should be conducted is about 75°.

It has been supposed that the corpuscles composing ferment are living beings, which nourish themselves with sugar and albumen, and secrete alcohol and carbonic acid.

**Ferrotype.** A name given by Mr. Hunt to a process in which an argentine photograph is developed with proto-sulphate of iron. The term is no longer in use.

**Ferrid-cyanogen.** Fe. 2, Cy. 6 = Cfdy. This assumed tribasic salt-radical has not been isolated. It is isomeric with ferro-cyanogen, being formed by the coalescence of two atoms of that compound.

**Ferrid-cyanide of Potassium**; or Red Prussiate of Potass. This magnificent salt is produced by passing chlorine through a solution of yellow prussiate of potass, (ferro-cyanide of potassium,) until the liquid ceases to precipitate prussian blue from the *per*-salts of iron. It is then filtered and evaporated, and yields right rhombic prismatic crystals of a ruby-red colour, which are anhydrous.

Ferrid-cyanide of potassium is soluble in about 4 parts of cold water, and nearly insoluble in alcohol.

This salt forms no precipitate with the *per*-salts of iron, but is a most delicate test of the *proto*-salts, with which it forms a blue precipitate, (Turnbull's blue.)

Ferrid-cyanide of potassium, or as it is sometimes called Ferricyanide of potassium, contains one atom of Ferrid-cyanogen and three atoms of potassium.

FERRO-CYANOGEN. Fe., $Cy._3 = Cfy$. A hypothetical bibasic salt-radical, supposed to contain 1 atom of iron and 3 atoms of cyanogen.

FERRO-CYANIDE OF POTASSIUM; or Yellow Prussiate of Potass; $K_2$, Cfy in the anhydrous state, or $K_2$ Cfy + 3 H O when in yellow crystals.

This salt is soluble in 4 parts of cold and 2 parts of hot water; it is insoluble in alcohol, which throws it down in yellow flakes from its aqueous solution. The crystals are four sided tables derived from a primary octahedron. The salt is not poisonous. When in crystals, the oxygen and hydrogen of the water of crystallization are exactly in such proportions as are required to convert the metals into protoxides and the cyanogen into hydrocyanic acid (prussic acid).

Ferro-cyanide of potassium is prepared as an article of commerce by putting chips of hoofs, animal horns, woollen rags, greaves, &c. into an *iron* pot, and burning them at a very high heat with potash, so as to form what is called "prussiate cake." This, when cold, is lixiviated with water, and evaporated. The resulting crystals are an impure ferro-cyanide of potassium. These are purified by being redissolved and recrystallized. The vessels and stirrers used in the operation should be of iron, as they then supply the iron contained in the salt. If not in sufficient quantity, iron filings should be added.

FILTRATION. This is a process for separating a liquid from the insoluble matter which it may contain. The liquid to be filtered is made to pass through a porous substance, such as unsized paper, porous earthenware, cloth, sand, &c. When common blotting paper is used it should first be washed with dilute muriatic acid, in order to remove some lime and iron which it generally contains. Filter papers are generally cut round, and the sides folded in puckers like a fan. They are then placed in a glass funnel, the diameter of which should be about three-fourths of its height, measured from the neck. The liquid should be poured into the funnel very gently along a glass rod. A filter covered with sediment may be conveniently washed by squirting water against it from a small syringe. Linen or calico should be used for filtering weak alkaline liquids, and flannel or felt-stuff for weak acid ones. These filter bags are made like a fool's cap, and have a wooden hoop at the top. Cotton wool, put into the neck of a glass funnel, makes a good filter for many purposes. Strong acids and alkalies should be filtered through a layer of pounded glass, quartz, clean sand, or bruised charcoal.

Sometimes the liquid is made to *ascend* in the filter by hydrostatic pressure. This is often a very good plan.

Volatile liquids, such as ether, collodion, benzole, &c., should be filtered under an air-tight vessel; or very rapidly, by exhausting the air from the vessel which is to contain the filtered liquid, and into which the end of the funnel is fitted air-tight.

**Fixing.** By this term is meant, in the daguerreotype process, the real fixation of the image to the plate by means of a boiling hot solution of sel d'or. The image can then no longer be rubbed off by the finger. In the ordinary collodion and paper processes the term "fixing" is improperly used to denote the removal of the sensitive material from the tablet, when the picture itself is in other respects completed.

**Flame.** The combustion of an inflammable vapour mixed with air; or according to some, "luminous gaseous matter." The luminosity of a flame depends chiefly on the presence of particles of solid matter. For instance, the flame of burning hydrogen is intensely hot and very feebly luminous; but if a little lime be dusted into it, the particles become intensely luminous. In general, it appears that the greater the *heat* of a flame the less the *light*, and conversely. If the top of the glass chimney of an oil lamp be contracted there is less escape of smoke, more combustion of solid matter, and the light is increased with a diminution of the oil consumed. In the case of the flame of a candle or spirit lamp, combustion only takes place at the outer surface of the flame and not in the centre; this may be proved by inserting a tube into the hollow of the flame, when the inflammable vapour will pass up it, and may be lighted at its other extremity. In the Argand lamp the wick is cylindrical, and the inside of the flame is supplied with air.

Flame can only exist at a very high temperature. If a piece of wire gauze be laid across a flame it conducts away some of the heat, and the combustible vapour, cooled by passing through the the gauze, passes off on the upper side without flame. This is the principle on which Davy's safety lamp is constructed.

**Flint Glass.** The composition of a good flint glass, S.G. 3·2, is as follows:—120 parts of fine clear white sand, 40 purified pearlash, 35 litharge, (oxide of lead, or "minium,") 13 nitre, and a small quantity of black oxide of manganese.

Flint glass is distinguished from crown glass by the absence of colour, and its higher refractive power. The lead, which is absent in crown glass, renders the flint glass more fusible, and increases its refractive power, giving it great brilliancy when cut, but it has some disadvantages, for glass containing lead is softer and more easily scratched; and it is difficult to obtain it of equal density throughout, and free from wavy marks or striæ.

When borate of lead is added to glass the density and refractive power are raised to the maximum at present known. *See* "Glass."

FLOWERS, COLOURED JUICES OF. Some of the coloured juices of flowers have been shown by Sir John Herschel and M. Chevreul to be sensitive to light, but none of them have yet been employed in photography. The reader is referred to Sir John Herschel's memoir on this subject in the "Philosophical Transactions," Part 2, for 1842, for further information.

FLUORESCENCE. This term has been introduced by Professor Stokes to denote a remarkable property possessed by certain substances with respect to light, and it has been adopted from the fact that fluor spar exhibits the phenomenon in a marked degree.

Suppose a trough, the sides and ends of which are made of plate glass, to be filled with a solution of sulphate of quinine. A ray of sunshine is admitted through a small hole in a shutter, and passed through a prism so as to be decomposed into rays of the prismatic colours. The trough, with its solution, is then placed so as to receive and transmit the solar spectrum. On looking through the ends of the trough, the luminous and least refrangible rays are seen to be transmitted, while the extreme violet rays are absorbed, and seen to penetrate only to a certain depth in the liquid; and in addition to this, rays beyond the violet, which were before invisible, are now rendered visible, and appear of a celestial blue colour, penetrating to a certain depth, and then disappearing.

If a piece of sensitive photographic paper be placed so as to receive the spectrum transmitted through the fluid, it is found that the usual darkening at and beyond the violet end of it is wanting.

A block of yellow uranium glass possesses a similar property to the solution of sulphate of quinine. So do æsculine, and other substances.

For further particulars of this curious phenomenon, the reader is referred to Mr. Stokes's original paper in the "Philosophical Transactions" for the year 1852.

It has been said that fluorescent bodies have the property not only of rendering the invisible rays visible, but of imparting chemical action to the luminous rays. This assertion must, however, be received with caution, and will probably turn out to be erroneous.

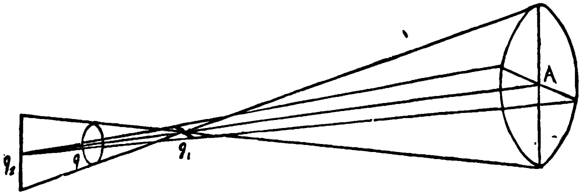
Mr. Stokes is of opinion that "the phenomena of internal dispersion oppose fresh difficulties to the supposition of a difference of nature in luminous, chemical, and phosphorogenic rays, but are perfectly conformable to the supposition that the production of light, of chemical changes, and of phosphoric excitement, are merely different effects of the same cause."

**Fluorine.** $F=7$. This is a hypothetical elementary body, which has not yet been isolated.

**Fluoride of Potassium.** $KF=59$. This salt is sometimes used in photography, but its good effects are very questionable. It is composed probably of one atom of potassium, and one of fluorine. It is deliquescent, and bears intense heat without change. Its solution acts upon glass.

**Fluoride of Silver** is a soluble compound which does not crystallize. It fuses when heated, and is reduced by exposure to light.

**Focal Lines.** When a small oblique pencil is reflected or refracted at a spherical surface, or refracted at a plane surface, the reflected or refracted pencil does not come to a "geometrical focus," or "least circle of aberration," but all the rays composing it pass through two straight lines (or elongated figures of 8), situated in planes at right angles to each other, and called "primary, and secondary focal lines."



For instance, suppose the circle at A, situated in a plane perpendicular to that of the paper, to be the base of a small pencil which has suffered oblique reflection or refraction. Then all the rays composing this pencil will first pass through the "primary focal line" $q_1$, which is *perpendicular* to the plane of the paper, and afterwards through the "secondary focal line" $q_2$, which is *in* the plane of the paper. The reason of this it would be out of place to discuss in the present work; the fact must be taken for granted; the demonstration of it will be found in Coddington's "Treatise on Optics." If a section be made of the curious solid formed by the pencil between the focal lines, at a point $q$ exactly midway between them, that section will be a circle, and it is the nearest approach that the pencil can have to a focus. This circle is called the "circle of least confusion."

The proportions of the figure are, of necessity, greatly exaggerated. The distance between the focal lines is in general very small compared with the distance of either of them from A; but the distance $q_1$ $q_2$, and also the diameter of the circle of least confusion, increase as the obliquity of the incident pencil increases.

FOCIMETER. This is an instrument employed by M. Claudet for finding the chemical focus of a lens which has not been properly achromatized.

A number of boards are arranged in a spiral about a horizontal axis, at different distances, and each board is painted white, and inscribed with a black letter. These boards are so placed as to be all visible together from the lens. If, when one of them is in exact visual focus, another is found to come out more distinctly in the photograph, it is evident that the visual and chemical foci do not coincide, and the lens should then be rejected as unfit for use, for it will be seen by referring to the article on Depth of Focus, that a lens whose chemical and visual foci do not coincide cannot give such perfect definition as one in which they do, other qualities being equal.

FOCUS. A focus is either "real" or "virtual." A "real" focus is a point through which an assemblage of rays actually pass. A "virtual" focus one through which their *directions* if produced forwards or backwards *would* pass.

A lens is said to have "positive focus" when the focus of a parallel pencil refracted through it is on the *same* side of it as the origin of light. A *concave* lens has therefore *positive* focal length.

A lens is said to have "negative focus" when the focus of a parallel pencil refracted through it is on the *opposite* side of it to the origin of light. A *convex* lens has therefore *negative* focal length.

In the former case the focus of the pencil is "virtual," in the latter case "real."

The *principal* focus of a lens, whether positive or negative, is the focus of a pencil of *parallel* rays after refraction through it.

The *equivalent* focal length of a combination of lenses having negative focus, is equal to the focal length of a single lens which, when presented to the same objects, gives an image of the same size as the combination.

FOCUSSING GLASS. This is a magnifier used for the purpose of magnifying the image on the ground glass, and enabling the operator to get it into better focus. A good form is that of the Ramsden's Eye Piece of a telescope, which consists of two equal single plano-convex lenses, placed with their plane sides outwards, and at a distance apart equal to two-thirds of the focal length of either. When in use the image on the ground glass must be in the principal focus (or thereabouts) of the eye-piece or focussing glass. It must be remembered that Ramsden's Eye Piece is not achromatic.

FOG. FOGGING. When a precipitate is thrown down over the entire plate by the action of the developer, so as to obscure the transparency of the glass when looked through, that precipitate is called "fog," and the picture is said to be "fogged." The principal causes of fog are—want of sufficient acid in the process, chemicals out of order, rough or dirty plates, and diffused light either in the camera or dark room. A frequent cause of fog is the want of a protecting tube in front of the lens, and a diaphragm within the camera.

FORMIC ACID. $C_2 H O_3 = 37$.

This acid was first discovered by Fisher in the red ant, (formica rufa); hence its name.

Formic acid and the alkaline formiates are reducing agents, and reduce the oxides of the noble metals, the acid being oxidized into carbonic acid.

Formic acid was originally obtained by distilling the ants with water; but the principal processes now employed for producing it are as follow:—

1st. 10 parts of starch, 37 of binoxide of manganese, 30 of water, and 30 of sulphuric acid are distilled in a retort (the capacity of which should be at least ten times that of the mixture), until 38 parts have passed over.

2nd. Concentrated formiate of soda and sulphuric acid distilled together yield very strong fuming formic acid, containing only 1 atom of water, but the sulphuric acid must not be in excess.

Formic acid is a colourless and slightly fuming liquid of a pungent odour, and acting as a caustic upon the skin. It freezes at 30°, and its S. G. at 60° is 1·235. It boils at 210°, yielding an inflammable vapour, which burns with a blue flame.

**FORMIATES.** The affinity of formic acid for bases far exceeds that of acetic acid. Most of the formiates are soluble in water.

**FORMIATE OF SILVER.** By mixing concentrated solutions of neutral nitrate of silver and slightly acid formiate of potass, nitrate of potass and formiate of silver are produced. The latter salt is thrown down as a white crystalline precipitate, which soon blackens in the light, and when neutral is converted into metallic silver, carbonic acid, and formic acid.

**FRAUNHOFER'S LINES IN THE SPECTRUM.** *See* "Spectrum."

**FREEZING MIXTURES** *See* "Table of Freezing Mixtures" at the end.

**FRENCH CEMENT.** Gum-water thickened with powdered starch. A little lemon juice is sometimes added. It keeps good for a long time.

**FRENCH POLISH.** Dissolve with a gentle heat 22 ounces of shellac in 80 ounces of rectified alcohol.

French polish is mixed with a few drops of oil at the time of application, and applied to the wood with a ball of cotton-wool; it is then rubbed briskly in the direction of the fibre, and finished, after drying by friction, with tripoli and oil.

**FULLER'S EARTH.** This is a greenish or yellowish grey powder found in different parts of England. It is used for removing grease spots, and also for decolorizing old nitrate baths, which is effected by filtering them through it. It is composed of silica, 53 parts; alumina, 10; red oxide of iron, 9·75; magnesia, 1·25; lime, 5, and a trace of potash.

**FULMINATING GOLD.** Subaurate of ammonia. $2\,NH_3, Au.\,O_3$.

When liquid ammonia is added to a concentrated solution of chloride of gold diluted with three times its weight of water, a yellowish brown precipitate is formed, which, when collected upon a filter, washed with water, and carefully dried at 212°, is fulminating gold. Acids and alkalis have little effect upon this substance. It is highly dangerous, and explodes, when dry, on the slightest friction.

**Fulminating Silver.** $2Ag. O, Cy._2, O_2$.

Liebig's process of preparing this dangerous substance is as follows:—

Dissolve 1 part of silver in 10 parts of nitric acid, S.G. 1·36 to 1·38. Pour the solution into 20 parts of alcohol, S.G. about ·830, and heat the mixture to ebullition. As soon as it begins to boil, remove the heat and let it cool; it then becomes turbid, and deposits fulminate of silver in the form of brilliant white needles. These must be washed and dried in very small quantities at a time, and with the greatest care. They should then be kept in a wide-mouthed bottle covered with paper.

This substance explodes with the slightest friction.

**Fusel Oil.** Oil of potato-spirit. An impurity contained in the alcohol obtained from potatoes, or beet-root treacle, or corn. It is supposed to be the alcohol of the amylic series, the base of which, amyle, ($C_{10} H_{11}$), has not, as yet, been isolated. This impurity in alcohol, when introduced into collodion, is believed to be injurious. To avoid it, the alcohol used in photography should be obtained from the juice of the grape.

Fusel oil is a colourless liquid of a peculiar nauseous odour and acrid taste. It mixes in all proportions with alcohol and ether, but not with water. Its S.G. is ·812. It boils at 270°, and freezes at 4°.

**Fusible Metal.** This metal fuses at the temperature of boiling water. It is composed of—

| | |
|---|---|
| Bismuth . . . . | 8 parts. |
| Lead . . . . | 5 ,, |
| Tin . . . . | 3 ,, |

and sometimes 1 part of mercury is added.

**Gall.** Ox-gall. The bile of the ox. Bile is a secretion which is separated from the venous blood in the liver. It is supposed to be a saponaceous compound in which an organic acid is combined with soda. Ox-gall is of a dingy green colour, transparent, and viscid; having a peculiar odour and a nauseously bitter taste. It has a slightly alkaline reaction, and mixes in all proportions with water.

Ox-gall may be clarified in the following manner:—Take the gall of newly killed oxen, and let it settle for 12 or 15 hours in a basin. Pour the supernatant liquor off the sediment into an evaporating dish, and boil it until it is somewhat thick. Then, spread it upon a dish, and put it before a fire until it becomes nearly dry. In this state it may be kept for years in jelly pots covered with paper. When required for use a piece of it the size of a pea is to be dissolved in a table-spoonful of water.

Ox-gall may be rendered perfectly colourless in the following manner:—To a pint of gall, boiled and skimmed, add one ounce of fine powdered alum, and leave the mixture on the fire till the alum is dissolved. When cold pour it into a bottle, and cork it loosely. Next, treat another pint of gall in exactly the same way, only substituting salt for alum. In about three months these preparations will deposit a thick sediment. Then decant the fluid portion of each, and mix them. A precipitate is immediately formed which takes down the colouring matter, and the supernatant liquid may then be filtered, and is as transparent and colourless as water.

Clarified ox-gall combines readily with colouring matters or pigments, and gives them solidity, either by being mixed with them, or passed over them upon paper. It increases the brilliancy and durability of ultramarine, carmine, green, and in general of all delicate colours, while it contributes to make them spread more evenly upon paper, ivory, &c. When mixed with gum arabic it thickens the colours without making them glisten, and prevents the gum from cracking, and fixes the colours so well that others may be applied over them. Along with lamp black and gum it forms a good imitation of Indian ink. When a coat of ox-gall is put upon drawings made with black lead, or crayons, the lines can no longer be effaced, but may be painted over with a variety of colours previously mixed with the same ox-gall. Miniature painters find great advantage in using it. When passed over ivory it removes the unctuous matter from its surface; and when ground with the colours makes them spread with the greatest ease, and renders them fast. It serves also for transparencies; being first passed over the oiled, or waxed, or varnished paper, and allowed to dry. The colours mixed with the gall are then applied, and cannot afterwards be removed by any means. It is useful to the photographer in blackening the skies of waxed-paper negatives, for when mixed with the Indian ink it causes it to flow more readily on the greasy surface of the wax.

Ox-gall is used for taking out spots of grease and oil.

This substance has been described at some length because it is not only very useful to the colourist of photographs, but may also turn out to be of some utility in the new methods of photographic printing in which pigments are fixed to the paper by means of bichromate of potass reduced by light.

**GALLATES.** The salts formed with gallic acid; which, according to Liebig, is bibasic.

The basic salts of gallic acid when exposed to air absorb oxygen, and acquire various shades of yellow and brown, till they ultimately blacken, in consequence of the formation of tanno-metanic acid, ($C_{14} H_4 O_7 + 2 H O$). In consequence of this property some of the gallates are more energetic developers in photography than gallic acid. Gallate of lead is an instance of this; for if acetate of lead be added to gallic acid an image may be developed very speedily which would not be brought out by gallic acid alone.

**GALLATE OF AMMONIA.** A white crystalline powder obtained by passing gaseous ammonia into an alcoholic solution of gallic acid. It is soluble in water.

**GALLATE OF POTASS.** When an alcoholic solution of potass is dropped into an alcoholic solution of gallic acid till green streaks remain on the surface, a white crystalline precipitate falls, which assumes a greenish hue by exposure to air, and becomes brown when dissolved in water.

**GALLATE OF SODA.** A white crystalline powder which forms a brown aqueous solution, and is obtained in the same way as gallate of potass.

**GALLATE OF IRON.** When gallic acid is added to cold solutions of the persalts of iron they become dark blue, which colour disappears on the application of heat, the peroxide losing oxygen, and carbonic acid being evolved.

The gallate of protoxide of iron is a colourless soluble compound, but becomes red, violet, and finally dark blue by absorption of oxygen, still however remaining soluble, till at length it blackens and is precipitated. It is then a gallate of the black oxide of iron, ($Fe._3 O_4$). It forms the principal part of the colouring matter of writing ink.

**GALLATE OF LEAD.** When acetate of lead is added to a *hot* solution of gallic acid, leaving the latter in excess, a grey crystalline powder falls. When a solution of gallic acid is added to a boiling solution of acetate of lead, the latter being in excess, a yellow crystalline basic gallate falls.

Collodion negatives may sometimes be fully developed, after a very short exposure, by the following process:—

First pour over the plate a saturated solution of gallic acid. Let it remain a minute or so. No image appears. Then pour it off into the measure, and add to it a few drops of a solution of acetate of lead. The mixture becomes milky from the formation of gallate of lead. Now pour it over the plate, and the picture immediately appears, and may be developed in the course of a few minutes to a dense and good negative, adding a few drops of nitrate of silver, if required.

GALLATE OF SILVER. If gallic acid be added to a solution of nitrate of silver, the mixture soon becomes discoloured, and if left undisturbed for some hours, a dark brown powder is precipitated. This however does not appear to be gallate of silver, and it is questionable whether there is any such salt, for the gallic acid most probably reduces the oxide of silver to suboxide, and becomes itself oxidized. The brown powder is most probably metagallate of silver, but its exact composition has not yet been ascertained.

If gallic acid be added to ammonia-nitrate of silver (oxide of silver dissolved in ammonia or nitrate of ammonia), the solution is immediately decomposed, and a brown powder precipitated, which, as in the former case, is of unknown composition.

If an acid be added to the solution of nitrate of silver, the decomposition of the solution is in general retarded for some minutes, or even for many hours, but it eventually takes place, even in the dark.

GALLIC ACID. $C_7 H O_3 + 2 H O$.

This acid was discovered by Scheele in 1786. It may be obtained as follows:—

Powdered galls are mixed with water, and the paste exposed for some weeks to the air, at a temperature of from 70° to 75°, adding water occasionally to prevent the paste from drying. The powder swells and becomes mouldy; and when the magma is exposed to pressure, a quantity of coloured liquor may be squeezed out. The residue or cake is then boiled in water, and the solution filtered while hot. On cooling, it deposits crystals of gallic acid, which may be purified by re-dissolving and boiling with a little animal charcoal. The filtered solution then deposits the gallic acid in white silky crystals. These are of a slightly sour and astringent taste, soluble in 100 parts of cold, and three parts of boiling water; readily soluble in alcohol, and sparingly soluble in ether.

Gallic acid is obtained in the above process by the oxidation of the tannic acid contained in the galls, by exposure to air. It is a feeble acid, and scarcely reddens litmus paper. It is a most important agent in photography, from its deoxidizing property. The products of its oxidation have not yet been thoroughly investigated.

The aqueous solution of gallic acid becomes mouldy and discoloured by keeping.

Gallic acid gives no precipitate with gelatine.

**Galls.** The gall-nut is an excrescence which forms upon the branches and shoots of the *Quercus infectoria*, being produced by the puncture of the female of the *Cynips gallæ tinctoriæ*, or gall wasp, which insect deposits its ovum in the puncture, and occasions the excrescence, or gall, within which the larva is developed, and when the insect is perfect it eats its way out. The best galls, known in commerce as black or blue galls, are gathered before the insect has escaped; the white galls are those from which the insect has departed, and are consequently perforated with a small circular hole. They are of a brownish or dingy yellow colour, but less heavy and astringent than the others. Gall-nuts are chiefly imported from Turkey, and have long been used as a source of black dye, and in the manufacture of writing ink. They contain a larger quantity of tannic acid than any other known vegetable product.

The insect which produces the gall-nut is about a quarter of an inch in length, and when the wings are expanded, nearly an inch in breadth. It is to be found chiefly in Asia Minor and Turkey, and is of a dirty yellowish-brown colour.

The *Quercus infectoria*, or gall oak, is found chiefly in Asia Minor.

Infusion of galls is a chemical antidote in cases of poisoning by opium, or nux vomica.

**Galvanized Iron.** Iron dipped into melted zinc, the surface of which is protected from the air by a layer of sal-ammoniac. On removing the iron it is found coated with a thin layer of zinc, which protects it for a considerable time from rusting.

**Gamboge.** A gum resin, concreted from the milky juice which exudes from the *Gambogia gutta*, and *Guttæfera vera*, trees native in Ceylon and Siam. It consists of about 85 parts of a red resin soluble in alcohol, and 15 parts of gum. It is a valuable pigment, and may be used for painting out the skies of negatives.

GELATINE. $C_{13}\,H_{10}\,O_5\,N_2$. This substance is produced by the action of hot water on the membranous tissues of animals. To obtain it, such substances as clippings of hides, hoofs, horns, calves' feet, cow's heel, sheep's trotters, pig's pettitoes, certain membranes, &c., are cleansed in cold water and then boiled. The solution so obtained is freed from fat, and any deposit, by skimming and straining, and allowed to form a jelly on cooling. This is called *size*, and when cut into slices and dried is called *glue*.

The purest form of gelatine is *isinglass*, which is obtained in Russia from the air bladder and sound of a species of sturgeon.

Size is sometimes obtained from the waste of vellum, parchment, and some kinds of white leather, and also from bones. It may be rendered inodorous, tasteless, and colourless, by the careful application of sulphurous acid. It is then called *patent gelatine*, *gremetine*, &c.

Gelatine gradually softens and swells in cold water but does not dissolve without heat. It absorbs three or four times its weight of cold water. 1 part of isinglass dissolved in 100 of hot water gelatinizes on cooling, but in 150 parts remains liquid: the effect, however, varies with the temperature.

When a solution of gelatine is repeatedly boiled and cooled it loses its power of gelatinizing on cooling, and remains soluble and deliquescent. In this state it has been called by photographers *metagelatine*.

Gelatine is insoluble in absolute alcohol, and ether, and also in fixed and volatile oils. When alcohol is added to a warm and strong aqueous solution of gelatine, the gelatine separates as a white viscid substance; and if a drop of the same solution of gelatine be added to alcohol, ether, or collodion, the gelatine immediately rolls itself up into a white ball, and sinks to the bottom of the bottle.

Gelatine is soluble in all the dilute acids, differing essentially in this respect from albumen. Of these, the acetic solution only gelatinizes on evaporation.

The dilute caustic alkalis, and ammonia, do not prevent the gelatinization of gelatine, but often throw down a portion of phosphate of lime. When gelatine is dissolved in a cold dilute solution of caustic potass, and exactly neutralized with acetic acid, the evaporated liquor does not gelatinize on cooling; it leaves a residue of altered gelatine combined with acetate of potass, which is soluble in alcohol. This substance might in certain cases be added to collodion to increase the density of the negative; or it might be used as a preservative solution to be applied to a sensitive plate.

Tannin precipitates gelatine from its solution as a dense white curdy precipitate, called tanno-gelatine. It is on this principle that leather is produced by the long soaking of hides in infusion of oak bark. Tannin is a very delicate test of gelatine, for when added to a solution of 1 part of gelatine in 5000 of water a cloudiness is produced. Sulphate of platina produces the same effect, and is the better test of the two, as it does not act in a similar way on albumen, as tannin does. A mixture of salt and alum also forms a white precipitate with gelatine.

Gelatine is capable of combining with some of the metallic oxides; for instance, with the oxides of iron, chromium, lead, tin, mercury, silver, gold, and platinum, its combination with silver and gold being effected by means of light, for it does not readily alter the colour of their solutions, if kept in the dark.

Gelatine has many important uses in photography, and enters largely into the sizing of English photographic papers.

**German Silver.** This is an alloy of nickel. The common sort is composed of copper 8, nickle 2, zinc 3½. A better sort has one part more of nickel; and the best sort, called *Electrum*, has two parts more of nickel. This last has a tinge of blue like very highly polished silver, and tarnishes less easily than silver. Objects may be electro-plated with nickel in the same way as with copper; using either the sulphate or chloride of nickel. German silver is superior to brass for optical instruments.

**Gilding Dissolvent.** This liquid is used for obliterating the images which have been fixed by sel d'or upon daguerreotype plates. Its exact composition has not been published, but it, no doubt, contains nitro-hydrochloric acid, disguised in some way. A mixture of salt and dilute nitric acid, or of nitre and dilute hydrochloric acid, will answer the purpose equally well.

**Glass.** Glass is a mixture of various insoluble silicates with excess of silica, and devoid of crystalline structure. The alkaline silicates, when in a state of fusion, have the power of dissolving a large quantity of silica.

There are two principal varieties of glass. The first comprises crown and plate glass, and is composed principally of silica, potass, and lime; the second, called flint glass, contains, in addition, silicate of lead; the lead promoting fusibility, and increasing the density, lustre, and refractive power.

The principle of the glass manufacture is very simple. Silica, in the shape of fine sand, is heated with carbonate of potass or soda, and slaked lime, or oxide of lead. At a high temperature, fusion and combination occur, and carbonic acid is expelled. When the melted mass has become clear and free from air bubbles, it is left to cool slowly until it assumes the peculiar tenacious condition suitable for working.

Crown and plate glass have a greenish colour; flint glass is colourless, and has a higher refractive index. Plate glass is cast upon a flat metal table, rolled, and, after very careful annealing, ground true and polished by machinery. (*See* "Plate Glass.") The large circular tables of crown glass are made by the glass blower. A long iron tube, called the blow-pipe, with a wooden mouthpiece, has its end dipped into the tenacious, soft, semi-fused glass in the glass pot. The lump of glass thus removed is then blown into a flask. An iron rod, called a pontil, is then dipped into the glass pot, and applied to the bottom of the flask so as to form a handle to it. The blow-pipe is then detached from the neck of the flask, which is again heated in the furnace, and then suddenly turned with great rapidity, so that the centrifugal force causes it to assume the shape of a flat disc. This done it is removed from the pontil, leaving a great knob or bull's eye of glass in the centre of the sheet, and put into the annealing oven, where it is allowed to cool slowly. Unless glass is *annealed*, or allowed to cool very slowly in this way, it becomes exceedingly brittle.

Tables of crown glass made in this way exhibit an exceedingly fine polished surface, although not strictly flat, like that of plate glass. Sheet glass is made by blowing a hollow cylinder, then cutting it lengthwise with a red hot iron, and spreading it open upon a flat table.

Glass is coloured by the addition of various metallic oxides. Oxide of cobalt gives deep blue; oxide of manganese, amethyst or black; sub-oxide of copper, ruby-red; black oxide of copper, green; the oxides of iron, dull green or brown; oxide of uranium, yellow; oxide of silver, yellow; purple of cassius, a ruby tint; oxide of antimony, yellow; oxide of chromium, fine reds and greens.

Opaque white glass, called white enamel, is made by adding oxide of tin.

The colouring oxide is either added to the glass in the glass pot, or applied afterwards to the surface, and burnt in.

Kane gives the following tabular view of the composition of several kinds of Glass. (Elem. Chem., 720.)

| Constituents. | Hard White Glass. |  | Crown Glass. |  | Bottle Glass. |  | Crystal. | Flint Glass. |  |
|---|---|---|---|---|---|---|---|---|---|
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Silica | 71·7 | 69·2 | 62·8 | 69·2 | 60·4 | 53·5 | 59·2 | 51·9 | 42·5 |
| Potass | 12·7 | 15·8 | 22·1 | 8· | 3·2 | 5·5 | 9· | 13·8 | 11·7 |
| Soda | 2·5 | 3· |  | 3· |  |  |  |  |  |
| Lime | 10·3 | 7·6 | 12·5 | 13· | 20·7 | 29·2 |  |  | ·5 |
| Alumina | ·4 | 1·2 |  | 3·6 | 10·4 | 6· |  |  | 1·8 |
| Magnesia |  | 2· | 2·6 | ·6 | ·6 |  |  |  |  |
| Oxide of Iron | ·3 | ·5 |  | 1·6 | 3·8 | 5·8 | ·4 |  |  |
| ——— Manganese | ·2 |  |  |  |  |  | 1· |  |  |
| ——— Lead |  |  |  |  |  |  | 8·2 | 33·8 | 43·5 |
|  | 98·1 | 99·3 | 100· | 99· | 99·1 | 100· | 97·8 | 99· | 100· |

No. 1, is the difficultly fusible Bohemian glass; No. 2, ordinary Bohemian glass; No. 3, English, and No. 4, German glass; Nos. 5 and 6, French glass; Nos. 7 and 8, English; No. 9, the celebrated optical glass of M. Guinaud, of Brennets, near Geneva.

All common glass, when reduced to fine powder is more or less acted on by boiling water, which separates the alkali; glass cannot therefore be considered as insoluble in water. If finely powdered glass be laid upon a piece of reddened litmus paper and moistened with water, the moisture restores the blue colour of the paper by dissolving out the alkali in the glass. The power of glass to resist the action of water, alkalis, acids, air, and light, is in general greater the higher the temperature employed in its manufacture, the smaller the proportion of its fluxes, and the more exact the chemical ratios of its constituents. Most crystal glass is affected by having water boiled in it for a considerable time: but crown glass, being poorer in alkali, and containing no lead, resists that action much longer and is better adapted for chemical purposes.

Air and light act upon glass, probably by their oxidizing property. Blueish and greenish coloured glasses become colourless by exposure, in consequence of the per-oxidation of the iron they contain. Glass containing manganese becomes purple-red by the per-oxidation of that metal from the same cause. Flint glass, which contains lead, is acted on by sulphuretted hydrogen, and the surface rendered opaque and iridescent. Achromatic lenses should, therefore, be carefully preserved from the action of sulphur.

Charcoal colours glass of a yellow or brownish tint, so that it is impossible to make glass in furnaces which smoke.

The discovery of glass is said by Pliny to be due to the following accident:—A merchant ship laden with natron, (soda,) being driven in a gale upon the coast of Syria at the mouth of the river Belus, the crew were compelled to cook their victuals ashore, and having placed lumps of the natron upon the sand as supports to the kettles, found to their surprise masses of transparent stone among the embers. According to Pliny and Strabo the glass works of Sidon and Alexandria were famous in their times, and produced beautiful articles which were cut, engraved, gilt, and stained of the most brilliant colours in imitation of gems. Some of the windows of Herculaneum appear to have been glazed.

For an account of the glass used in optical instruments *See* further particulars in the articles "Optical Glass," and "Plate Glass;" and for the method of grinding lenses, *See* "Lens."

**GLASS, SOLUBLE.** When silica is melted with twice its weight of carbonate of potass or soda, and the product treated with water, the greater part dissolves, yielding a solution from which acids precipitate gelatinous silica. This is the *soluble glass* mentioned by some chemical writers. Its solution has been used for rendering muslin and other cotton fabrics incombustible.

If stone or brick work be first washed over with the above solution of silicate of soda, and then with a solution of chloride of calcium, a double decomposition takes place by which common salt and silicate of lime are produced. The latter is an insoluble salt and forms a glaze on the surface to which it is applied, filling up the cavities and protecting it from the weather. It has been proposed to employ this process for architectural purposes, and it may perhaps find some uses in photography.

**GLASS, DRAYTON'S METHOD OF SILVERING.** Make an edging of wax all round the glass plate. Pour into the dish thus formed, a solution of ammonio-nitrate of silver to which a reducing agent, such as grape sugar, is added. In a short time the glass will be covered with a beautiful metallic coating of silver.

**GLASS DISHES.** Dishes are sometimes made of plate glass for holding the nitrate bath. The bottom is formed of one piece of plate glass, and the sides of strips cemented to it with marine glue. The edges and ends of these strips should be accurately ground. To cement them together the pieces are heated with a spirit lamp, and the glue rubbed on while still hot, and the pieces immediately applied together, and pressed into contact. It is by no means an easy operation, and dishes made in this way are rather dear. If an iron mould were made of the required size and shape, glass dishes might be cast, and these would be very useful in photography.

Dishes of plate glass should be enclosed in a wooden case, provided with a lid.

**GLAZIER'S PUTTY.** Whiting, or white lead, made into a paste with boiled linseed oil.

**GLUCOSE.** *See* "Grape Sugar."

**GLUE.** *See* "Gelatine."

**GLYCERINE.** $C_6 H_8 O_6$. (Gr. γλυκυς, sweet.) Glycerine is a sweet substance which may be extracted from fatty bodies and oils. In its purest form it is obtained in the following manner:—

Take equal parts of olive oil and finely ground litharge; put them into a basin with a little water, and set it on a sand bath moderately heated, continually stirring the liquid and adding fresh boiling water when necessary. In this way in a short time a soap or plaster of lead is formed. Add more water to this and remove the vessel from the fire, decant the liquor, filter it, and pass sulphuretted hydrogen through it to separate the lead; then filter again and concentrate the liquid as much as possible by evaporation without allowing it to be burned on the sand bath. Evaporate what remains under the receiver of an air pump. This is Glycerine. It is a transparent liquid without colour or smell, and of a syrupy consistence. Its S. G. at 60° is 1·27. Water combines with it in all proportions, and alcohol dissolves it readily, but it does not mix with ether or oils.

Glycerine is a neutral substance, and exhibits no tendency to combine either with acids or bases. It has but little action upon nitrate of silver, even in the light. Glycerine, if spread upon glass or paper, does not dry, but retains its moisture. From this circumstance, and its perfect neutrality, it may be employed in photography as a means of preserving the moisture of sensitive collodion films and papers.

Glycerine is decomposed by nitric acid, with the formation of oxalic acid, carbonic acid, and water. When, therefore, glycerine is used as a preservative fluid in photography, the nitrate bath should not contain free nitric acid.

A great many salts which are soluble in water, are also soluble in glycerine.

In the manufacture of soap, which consists in boiling a fatty substance containing glycerine with an alkali, the oil combines with the alkali, and glycerine remains. *See* "Saponification."

**GLYCYRRHIZINE.** This substance has been recommended by Mr. Hardwich to be added to collodion, in order, when necessary, to increase the density of the blacks of the negative. In this respect it acts like many other kinds of organic matter, in the mode described in the articles on the "Chemistry of Photography," and "Development."

Glycyrrhizine (Greek, γλυκυς sweet, ριζα a root) is a sugar, or sweet resin, obtained from the liquorice root. A strong infusion of liquorice root is slowly evaporated to a small bulk, and sulphuric acid added: a precipitate falls, containing sugar and albumen. This is to be washed in water acidulated with sulphuric acid, and afterwards in water; then digested in alcohol, which dissolves the glycyrrhizine and leaves the albumen. A solution of carbonate of potass is then dropped into the alcoholic solution till its acid is neutralized; it is then filtered and evaporated, and the sugar remains as a yellow transparent mass.

Liquorice sugar is easily soluble in water and alcohol, and has a tendency to combine with acids, bases, and salts, and occasions precipitates with most metallic salts. Its property of combining with suboxide of silver renders it useful in the processes of development when increased density in the precipitate is required. The best mode of using it is probably to add a drop or two of the alcoholic solution to the collodion. The sensitiveness of the film will then be diminished, and the intensity of the negative increased.

**GOLD.** Symbol Au.; Equivalent 200.

This valuable metal occurs in nature in a metallic state alloyed with silver or copper, and is then called *native gold.* The veins of gold are confined to primitive countries, but large quantities are collected in alluvial soils, and the beds of rivers. It is generally found in small nodules, and grains, but sometimes occurs in considerable masses weighing several pounds. The principal supplies of gold are from Australia and California, the Ural Mountains, the rivers on the west coast of Africa, and of Peru, Brazil, and Mexico.

Gold may be obtained pure by dissolving standard gold in aqua-regia (1 part by weight of nitric acid, and 2 of hydrochloric acid), evaporating to dryness, redissolving the dry mass in distilled water, filtering, acidulating with hydrochloric acid, and then adding a solution of proto-sulphate of iron. A brown powder falls, which after having been washed with dilute hydrochloric acid and distilled water is pure gold. It may be fused in a crucible with a little borax, and a button of gold obtained.

Proto-sulphate of iron is a very delicate test of the presence of gold, producing a blue tint in a solution containing not more than the 60,000th part of the metal. It also throws down the whole of the gold from its solutions.

Gold melts at a bright red heat. It is so malleable that a single grain may be extended over 56 square inches of surface, and so ductile that a grain may be drawn out into 500 feet of wire.

The pure acids have scarcely any action upon pure gold; neither has sulphur, nor sulphuretted hydrogen. Chlorine, iodine, and bromine act upon it. Gold forms various interesting double salts, and its oxide combines with the alkalies. These compounds are described in their proper places. Sulphide of potassium is a solvent of gold, and forms with it a double sulphide of gold and potassium. Metallic gold, in a state of fine division, has sometimes a purple tint.

**GOLD, OXIDE OF.** There are two well defined oxides of gold, viz., the protoxide, Au. O, and the peroxide, $Au.\ O_3$, sometimes called auric acid.

Protoxide of gold is produced by evaporating a solution of the perchloride to dryness, and stirring the residue till it acquires a yellow colour, taking care that the temperature never rises above 300°. Caustic potass is then added in solution, and protoxide of gold separates, the liquid becoming deep yellow in consequence of the solution of a part of the oxide in the alkali. If this be filtered and nitric acid added so as exactly to saturate the potass, hydrated protoxide of gold falls. It is of a deep violet colour, almost approaching to black, insoluble in water and alcohol, and not decomposed till heated to 400°, when it parts with oxygen. It is not soluble in nitric, sulphuric, or acetic acids, only in aqua-regia. Hydrochloric acid converts it into metallic gold and perchloride of gold. Potass and soda dissolve it in its nascent state, and with ammonia it forms a purple detonating compound. The protoxide of gold is important in photography as it is possible that, combined with organic matter, it may be the compound which gives the violet colour to positives that are toned with gold.

The peroxide of gold, or auric acid, is obtained by adding carbonate of potass to neutral chloride of gold, and digesting at 170°. Carbonic acid escapes, and the hydrated peroxide subsides.

**GRAPE SUGAR; GLUCOSE.** $C_{24}\ H_{28}\ O_{28}$.

This modification of sugar, sometimes called "Glucose," is interesting in photography from the fact of its reducing the oxides of the noble metals to the metallic state without the aid of light; a property which is not possessed by cane sugar. It forms the hard saccharine concretion found in honey, raisins, dried figs, etc., and is contained abundantly in the juice of the grape. It may also be produced from starch by the action of acids. It is neither so sweet, nor so soluble in water as cane sugar.

The expressed juice of the grape contains 30 or 40 per cent. of grape sugar. To obtain it, the juice is neutralized with chalk. strained and filtered, mixed with a little white of egg, boiled, skimmed, and evaporated till of the S. G. 1·32. It is then allowed to cool, and in a few days it concretes into a solid mass, which is drained, and then dried by pressure. It affords about 3 parts of dried grape sugar and 1 of syrup. The sugar may be rendered white by boiling it with charcoal.

Grape sugar is sometimes made by acting upon potato-starch with dilute sulphuric acid. The process is hardly of sufficient interest to the photographer to be worthy of description in this place.

Ground Glass. A sheet of ground glass is generally used for the focussing screen of the camera. It should be as finely ground as possible, and the best way to secure this is to use plate glass which has not received the final polishing in the manufacture. A sheet of plate glass may be ground by hand, by rubbing with a smaller piece of thick plate, and the finest powdered emery moistened with water between. It takes three or four hours continuous labour to do this properly. The last and finest grinding may be given with a mixture of colcothar (red oxide of iron, iron rust,) and water, instead of emery.

The ground glass screen should be placed in the camera with the ground side next to the lens; and it will be found very useful to mark two diagonals across it, and also one central horizontal line, and an odd number of vertical lines, with a lead pencil.

A good substitute for a ground glass focussing screen is to coat a piece of plate glass with spirit varnish applied to a cold plate, and allowed to set without heat. When dry, it forms a semi-opaque film upon the glass. Benzole varnish with a little wax in solution also answers the purpose.

Guaiacum. A resinous exudation from the *Guaiacum officinale*, a lofty tree, native in Jamaica and St. Domingo. It is soluble to the extent of 90 per cent. in absolute alcohol. If a piece of paper be dipped in tincture of guaiacum, and exposed to the prismatic spectrum, it is oxidized, and becomes of a green tint in the violet rays; but in the red rays the green colour is said to be destroyed.

**Gum.** Gum is a substance which occurs largely in the vegetable kingdom, and is characterized by forming a viscid adhesive solution with water, which precipitates by the addition of alcohol a white magma. It occurs in the form of an exudation upon the bark of trees, and collects into drops, which gradually harden by exposure.

There are two principal modifications of gum, one of which is well represented by gum arabic, and the other by gum tragacanth.

**Gum Arabic.** This is the produce of various species of *acacia*, and is imported from the Levant, Barbary, Senegal, the Cape of Good Hope, and India. It is soluble in cold water, but more rapidly in boiling water. Its solution is acid, and reddens litmus paper, from the presence of permalate of lime. It is insoluble in alcohol, ether, and oils. It enters into combination with some of the metallic oxides.

**Gum Dragon.** Same as Gum Tragacanth.

**Gum Tragacanth.** This gum is obtained from the *Astralagus tragacanther*, which grows in Crete and the surrounding islands. It looks like twisted ribands, and is of a reddish white colour, nearly opaque, and a little ductile. When plunged into water it dissolves in part, swells considerably, and forms a thick mucilage, which when boiled with water resembles a solution of gum arabic. It is very difficult to pulverize, and should be heated to 212°, and pounded in a hot mortar.

**Gum Dammar,** or, more properly, Dammar Resin. This is a white resin brought from India, and obtained from the *Pinus dammara.* It is soluble in benzole, and makes a tolerably good varnish for photographs upon glass, which dries very quickly without heat. A portion only of Dammar is soluble in alcohol.

**Gun Cotton,** or Pyroxyline. The manufacture of this important substance is described in the article "Pyroxyline."

**Gutta percha.** This useful article is the produce of a very large and lofty forest tree called the *Isonandra gutta*, which is native in the islands of the Indian Archipelago. Some of its properties were first pointed out by Dr. W. Montgomerie in a letter to the Bengal Medical Board in 1843. When an incision is made in the bark of the above tree, a white substance exudes which becomes shortly, by exposure to air, hard and tough; this is pure gutta percha. Neither the wood nor fruit of the tree appear to be of any great value; and a full sized tree, when cut down and the gutta percha collected in bamboos, yields about 30 or 40 pounds of gutta percha.

Gutta percha is sometimes contaminated with organic matters, bits of bark, and foreign substances. To purify it, it is rasped in cold water, which removes the greater part of the soluble organic matters and salts, and also facilitates the removal of portions of wood and earthy matters, for gutta percha does not combine with any substance of this kind, but merely holds it mechanically. The raspings are then washed and left to soak in warm water for several hours, and are finally dried,heated to about 230°, and kneaded into lumps.

Gutta percha may be softened by hot water, and in that state moulded into any form, stretched into sheets or straps, drawn out into tubes or threads, &c., and on cooling completely it hardens and retains the form given to it. It does not possess at any temperature the peculiar elasticity of india-rubber.

Gutta percha resists the action of cold water and damp, and all those agents which promote fermentation. It is not acted on by alkalis, even when caustic and in their most concentrated form; nor by ammonia, saline solutions, water containing carbonic acid, the various vegetable and mineral acids, and alcoholic liquors.

Olive oil dissolves a small portion of it when hot, but precipitates it on cooling. Sulphuric acid with one equivalent of water colours it brown, and disintegrates it with a sensible evolution of sulphurous acid. Hydrochloric acid attacks it slowly, and renders it brittle at a temperature of 68°. Monohydrated nitric acid attacks it rapidly, with effervescence and an abundant evolution of fumes of hyponitrous acid.

Only a small portion of gutta percha can be dissolved, even with the aid of heat, in absolute alcohol or ether. Benzole and spirits of turpentine dissolve it partially when cold, and nearly completely when hot. Sulphide of carbon, and chloroform, dissolve it completely when cold; the solution becoming perfectly clear and almost colourless when filtered under a bell glass.

Gutta percha is sometimes vulcanized with sulphur, by a process patented by Mr. Hancock in 1847. It is sometimes treated with chloride of zinc. The object of these processes is to give it a hard glazed surface free from stickiness. Vulcanized gutta percha may be varnished with a mixture of oil and resin, and polished till it acquires the lustre of japanned wares.

Gutta percha is sometimes adulterated with the gums of other trees, plaster of paris, &c.

It is an exceedingly valuable material for the baths and dishes used in photography, but when employed for these purposes should be scrupulously pure.

It has a porous texture, and its cells contain air. They may be clearly seen in a thin film of gutta percha placed under a powerful microscope.

Gutta percha is of great value to the surgeon for forming splints for fractured bones, since it can easily be moulded to any shape when hot, and becomes sufficiently hard and rigid on cooling. It is also very useful for many surgical instruments.

HALO. Sometimes a halo, or line of light, is seen to surround the edges of dark objects in a photograph. It is produced by some peculiar action of light on iodide of silver, which is not yet understood. The effect is not due to the lens, since it occurs in positives taken by superposition and printed by development upon iodide of silver, without any indication of the kind existing in the negative. The effect may be frequently observed in daguerreotypes and collodion positives, and in collodion and paper negatives it shows itself as a black line surrounding the light parts of the negatives.

This singular halo is never observed when chloride of silver is used instead of iodide. It may be removed in some measure by adding a chloride to the iodizing solution. The chlorides most soluble in alcohol are those of magnesium, calcium, (not chloride of lime,) and zinc. This addition diminishes the sensitiveness of the plate or paper, but increases the density of the negative, and renders it more uniform in the opacity of the blacks.

HALOGENS. HALOID SALTS. (Greek, *αλς* sea salt, *ειδος* form.) Haloid salts are such as are formed by the combination of a salt radical such as chlorine, iodine, bromine, &c., with a metal such as sodium, cadmium, &c. Chloride of sodium, iodide of potassium, bromide of cadmium, &c., are haloid salts; and chlorine, bromine, iodine, &c. are called "halogens."

HELIOGRAPHY. (Greek *ἥλιος* the sun, *γραφω* to delineate.) Another name for photography.

**Hermetical Seal.** A vessel is said to be "hermetically sealed" when its lips are closed together perfectly by means of heat, as in the case of a thermometer tube. The term is derived from **Hermes**, the fabulous founder of Egyptian chemistry.

**Honey.** A sweet viscid liquor extracted by bees from the nectaries of flowers, and deposited by them, apparently without undergoing chemical change, in the waxen cells of their combs.

Honey is of two kinds, viz., virgin honey, and common honey. The former is that which flows spontaneously with a very gentle heat from the comb,—the latter that which is obtained by submitting the comb to pressure. The former is the purest, and is nearly colourless; the latter is thicker, darker coloured, and not so agreeable to the taste.

Virgin honey should be used in photography, and not the common kind, which is frequently adulterated.

Honey contains two distinct kinds of sugar; viz, grape sugar, and an uncrystallizable species of syrup. The former possesses considerable reducing properties, hence its use as a reducing agent in photography. The syrup only possesses these properties to a limited extent, and its value in photography chiefly consists in its not drying or crystallizing, but retaining its moisture for a long time when exposed to the air. Honey has therefore been employed as a means of preserving the moist condition of a sensitive collodion film; but it is evident that a simple syrup which does not contain a strong reducing agent, such as grape sugar, would be preferable to honey; golden syrup, for instance, which is a pure form of treacle, and free from grape sugar, is far better than honey; and perhaps glycerine may be found still better than any form of syrup. But this question is discussed under the head of "Preservative Processes;" *q. v.*

If inspissated honey be treated with absolute alcohol, the thin portion contains principally the uncrystallizable syrup, and the grape sugar remains for the most part undissolved, being less soluble in alcohol.

Honey is soon decomposed in contact with nitrate of silver.

**Honey-preservative Process.** *See* "Preservative Processes."

**Horn Silver.** Fused chloride of silver, sometimes called "luna cornea;" a grey semi-transparent concrete mass, which is darkened to a slaty tint by exposure to light. The melting point of horn silver is 500°, Faht. If heated much above that point it volatilizes in dense white fumes. When cooled slowly after fusion it has a tending to octahedral crystallization.

**Hungarian Solution.** This liquid is sometimes used in the daguerreotype process for exciting the plate at one operation. Its composition has not been published, but it is supposed to be a dilute alcoholic solution of iodine, bromine, and chlorine, in certain proportions. Its use is now nearly superseded by that of bromide of lime; *q. v.*

**Hydrate.** When water enters into direct combination with a body the compound is called a hydrate of that body. For instance, water combines energetically with slaked lime, and the compound is called "hydrate of lime." Sometimes water combines less energetically with bodies, and merely in such a way as to constitute what is called their water of crystallization, which may be expelled by heat; in this case the term hydrate is not employed.

**Hydriodates.** Salts formed by the combination of hydriodic acid with bases. Sometimes a salt is called a hydriodate of a base when it ought more properly to be termed an iodide of a metal. Iodide of potassium for instance contains no water of crystallization, and the term hydriodate of potass is therefore incorrectly applied to it. The same may be said of many hydrochlorates, hydrosulphates, &c.

**Hydriodic Acid.** $HI = 127$. This acid is a combination of equal volumes of hydrogen and iodine, which unite in the gaseous form without decrease of volume. It is obtained by gently heating 1 part of phosphorus, 14 of iodide of potassium, 20 of iodine, and a little water. The formula of the action is, according to Gmelin,

$$2\,KI + 5\,I + P + 7\,HO = 2\,KO, PO_5 + 7\,HI.$$

Hydriodic acid may also be formed by passing a mixture of hydrogen and the vapour of iodine, through a red hot iron tube. The acid gas may be collected over mercury, but is soon decomposed by the mercury, which takes a part of the iodine.

Hydriodic acid gas is extremely sour and reddens litmus paper, colourless, and exhales fumes in the air. It extinguishes flame, and is not inflammable. It may be liquefied under pressure, and becomes solid at a temperature of $-60°$ Faht. It is not permanent at a red heat. Chlorine decomposes hydriodic acid, producing hydrochloric acid and iodine, and chloride of iodine. Nitric acid decomposes it with great violence, and in general, oxidizing agents decompose it by forming water with the hydrogen, and liberating iodine.

Hydriodic acid gas mixes readily with water. The S. G. of the strongest liquid acid is 1·7. It becomes dark coloured when kept in contact with air, in consequence of a partial decomposition. Aqueous hydriodic acid may readily be produced by passing sulphuretted hydrogen through a mixture of iodine and water; the sulphur is precipitated, and hydriodic acid produced. On heating and filtering the liquor a pure solution of hydriodic acid is obtained.

**HYDRIODOUS ACID**; $HI_2$. A solution of iodide of potassium, or zinc, will take up a quantity of iodine equal to that which it already contains. These salts have been sometimes called "ioduretted iodides," and the acid has been termed "hydriodous acid."

**HYDRO-CARBON.** Hydrogen and carbon combine in a great many different proportions, forming compounds many of which possess considerable interest. It rarely happens, however, that these compounds can be obtained synthetically by actually mixing the ingredients; they are in general produced by the decomposition of organic matters.

Some of the principal hydro-carbons are as follows:

Light-carburetted hydrogen . . = $C\ H_2$
Olefiant gas . . . . . = $C_2\ H_2$
Bicarbide of hydrogen . . . = $C_6\ H_3$
Etherine . . . . . . = $C_4\ H_4$
Naphtha . . . . . = $C_6\ H_5$
Naphthalin . . . . . = $C_{10}\ H_4$

and also common coal gas, oil gas, resin gas, coal tar, and many analogous substances.

The characteristic properties of the hydro-carbons are their combustibility, and the energy with which they are in general decomposed by chlorine when exposed to light, the result being the production of hydrochloric acid, and the liberation of carbon. Some of the hydro-carbons are isomeric, and yet possess distinctive peculiarities.

Light-carburetted hydrogen may be produced artificially, by mixing 40 parts crystallized acetate of soda, 40 parts solid hydrate of potass, and 60 parts of powdered quick lime. When this mixture is strongly heated in a retort, the gas passes over, and may be collected over water. It is the fire damp of coal mines, and the marsh damp which proceeds from stagnant and decomposing mud.

Common coal gas is composed chiefly of carbon, hydrogen, and sulphur, and is produced by the destructive distillation of coal, the volatile substances passing over, and coke remaining in the retort. The volatile matters are first passed through a condenser kept cold by immersion in water, and here the water, tar, ammoniacal liquor and other condensable vapours are retained. The gases which pass over, and which consist chiefly of carburetted hydrogen, hydrogen, sulphuretted hydrogen, carbonic oxide, carbonic acid, nitrogen, and cyanogen, are then passed through a mixture of quick lime and water in a vessel called a purifier, by which a large portion of the sulphuretted hydrogen and carbonic acid are absorbed; the remaining mixed gases are then sufficiently pure for the ordinary purposes of illumination.

Olefiant Gas, and Naphtha are described in their proper places; *q. v.*

HYDROCHLORIC ACID; $H\ Cl.=37$. This acid is sometimes called "muriatic acid," and "chlorhydric acid." It is formed by combining equal volumes of hydrogen and chlorine, which unite without diminution of volume, the result being a strongly acid gas. The simplest mode of effecting this combination is to expose the mixed gases to light. In diffused daylight they combine gradually, but in strong sunshine at once, and with explosion. If a mixture of equal volumes of hydrogen and chlorine be collected over water in a tall graduated glass jar, and exposed to diffused light, the gases gradually combine and form hydrochloric acid; this is absorbed by the water, which has a strong affinity for it, as fast as it is formed, and the water therefore rises in the tube. It is found by this experiment that the quantity of acid produced is proportional to the time of exposure to light.

Hydrochloric acid is readily obtained by adding diluted sulphuric acid to common salt in a retort, and applying heat to the mixture. The chlorine of the salt combines with the hydrogen of the water to form hydrochloric acid, the sodium is oxidized, and sulphate of soda left in the retort.

Dry hydrochloric acid gas is colourless, and fumes in the air from its absorption of moisture. It is intensely sour, and combines readily with water. The S. G. of the strongest liquid acid is 1·210, and water takes up 500 times its bulk of the gas. It boils at 112°, and freezes at $-60°$.

The impurities in commercial liquid hydrochloric acid, and which give it a yellowish colour, are principally organic matter (from bits of cork, lute, &c.), a trace of bromine, chloride of iron, sulphuric acid, and sometimes nitric and sulphurous acids, and also a trace of used for etching upon glass, *See* "Etching by Photography." The fumes of hydrofluoric acid destroy the polish and dim the surface of glass. Focussing screens are sometimes made in this way instead of grinding the glass.

**Hydrogen.** H=1. (Greek, ὕδωρ water, and γεννειν to produce.)

Hydrogen is the lightest of all known bodies, and its atomic weight is therefore taken as the unit of the scale of equivalents. It may be obtained in a somewhat impure form by acting on some bits of zinc, or iron filings, with dilute sulphuric acid. Water is decomposed, its oxygen going to the metal to form a sulphate, and hydrogen being given off. The best proportions appear to be, zinc 3 parts, sulphuric acid 5 parts, water 25 parts. Pure hydrogen may be obtained by acting on pure water with an amalgam of potassium or sodium. Hydrogen may also be obtained by passing steam through a red-hot gun-barrel.

Hydrogen is inflammable, but extinguishes flame. When mixed with oxygen or atmospheric air in sufficient quantity it explodes with violence. It has a high power of refracting light. When pure it is colourless, tasteless, and nearly inodorous. Water only takes up about 1 per cent. of it.

Hydrogen plays an important part in many of the chemical changes produced by light. This matter will be found discussed in the article on the "Chemistry of Photography;" *q.v.*

Hydrogen is supposed by many chemists to be a metal in the form of vapour, and to be the acidifying principle of some acids. Take, for instance, sulphuric acid; this substance, so powerful an acid in its hydrated or common form, does not when pure and perfectly *anhydrous* redden litmus paper, or exhibit any acid properties. Other similar cases might be quoted.

**Hydrogen, Oxide of.** There are two oxides of hydrogen, viz., water, which is the protoxide; and oxygenated water, or peroxide of hydrogen, or ozone, about which very little is known at present. *See* "Water" and "Ozone."

**Hydrogen-Acids, or Hydracids.** These are the acids which hydrogen forms with chlorine, sulphur, iodine, &c.; and which are described under their various heads. The term "hydracid," is used in contradistinction to "oxacid," in which oxygen in combination with another element forms the electro-negative constituent of a salt.

HYDROMETER. An instrument for measuring the specific gravities of liquids. Its commonest form is a long graduated tube loaded at the bottom, and allowed to float in the liquid to be tested, the depth to which it sinks being indicated by the scale. The principle of the instrument consists in the fact, that a floating body displaces a quantity of liquid exactly equal in weight to itself. The hydrometer affords, therefore, a measure of the volume of the liquid necessary to counterbalance in weight the weight of the instrument; and by comparing these measures of volume when different liquids are tested, the specific gravities of the respective liquids may be compared and determined.

The most convenient form of hydrometer on this principle is that of Zanetti, manufactured at Manchester. It is sold in sets of six, and the S. G. is got by adding a cipher to the number of degrees indicated; the assumed temperature being 60° Faht.

The hydrometers of Twaddle, and Beaumé, are constructed on the same principle, but graduated differently. There are two forms of Beaumé's hydrometer; one for measuring the S. G. of liquids heavier than water, and called a "*pèse-acide*," or "*pèse-sirop*;" the other, for liquids lighter than water, and called a "*pèse-esprit.*" These instruments are much used both in France and England, and are sometimes called "Areometers."

An entirely different principle of construction has been adopted in the hydrometers of Nicholson, and Fahrenheit. In these instruments the line of flotation in water at 60° is marked, and when immersed in the liquid to be tested the instrument is loaded until it sinks to the same level,—the weight required to be added or removed determining the S. G. of the liquid.

The hydrometer does not afford an exact test of the strength of an *old* nitrate bath, because the bath acquires by use nitrate of potass and other contaminations, which increase its specific gravity.

HYDROSULPHATE OF AMMONIA; sulphide of ammonium: $NH_3$, HS.

The aqueous solution of this compound may be obtained by dividing a portion of liquor ammoniæ into two parts, saturating one with hydrosulphuric acid, and then adding it to the other. It forms a colourless liquid, which decomposes and turns brown in the air, and has a most offensive smell, like rotten eggs.

When ammonia is saturated with hydrosulphuric acid, hydrosulphate of sulphide of ammonium is produced, which is a double sulphur salt, the formula of which is $NH_4\,S+HS=51$.

If a few drops of sulphide of ammonium are added to a pint of water, and a fixed positive print immersed in it, the print darkens from red to brown, thence to purple and black, and becomes ultimately a pale yellow; exhibiting, in a few minutes, all the changes which a fading photograph usually undergoes. Unless the print is completely fixed before immersing it in this bath it is immediately discoloured all over with a brown coating of sulphide of silver.

HYDROSULPHURIC ACID; Sulphuretted hydrogen; $HS = 17$. Sometimes called hydro-thionic acid.

This gas is readily obtained by acting on proto-sulphide of iron with dilute sulphuric acid; or by heating in a flask equal parts of tallow and powdered sulphur. In the former case water is decomposed, the hydrogen combining with the sulphur to form hydrosulphuric acid, and the oxygen going to the iron to form protosulphate of iron. The second method yields the purest gas.

At ordinary temperatures hydrosulphuric acid is gaseous; it is liquefied under a pressure of 17 atmospheres, and becomes solid at a temperature of $-122°$ Faht. It is inflammable, but extinguishes flame; highly poisonous, and its odour extremely offensive, resembling that of rotten eggs. Cold water takes up about three times its volume of this gas, and the solution is slightly acid to litmus paper.

Hydrosulphuric acid throws down silver, gold, and many other metals from their solutions, by forming insoluble sulphides, of various colours; *See* "Sulphides." It combines with many of the basic sulphides and forms double sulphur salts..

Hydrosulphuric acid is immediately decomposed by iodine, chlorine, and bromine, and sulphur precipitated. It is also decomposed by nitric acid. In combination with potass, or soda, it is capable of dissolving gold, and forming a double sulphide of gold and potassium or sodium. Silver may probably be acted on in the same way, and the yellow material of a faded photograph may be a double sulphide of silver and sodium.

HYPOSULPHITE OF GOLD AND SODA. *See* "Sel d'or."

HYPOSULPHITE OF SILVER AND SODA; $2\,(Na.\,O,\,S_2\,O_2) + Ag.\,O,\,S_2\,O_2 + 2\,HO$.

When chloride of silver is dissolved in hyposulphite of soda, and the solution evaporated, lamellar crystals of the above salt are obtained. They are of a dirty grey colour, and contain two atoms of water. They are unaltered by exposure to air and light, are very soluble in water, and have a sweet taste. When the iodide, chloride, bromide, &c., of silver are dissolved in hyposulphite of soda, this double salt is produced, together with iodide, chloride, bromide, &c., of sodium. It is nearly insoluble in alcohol.

Hyposulphite of silver alone cannot be isolated. It is no sooner formed than it undergoes decomposition into sulphide of silver and sulphurous acid, unless excess of hyposulphite of soda be present; in which case a double salt is produced.

HYPOSULPHITE OF SODA. $Na. O, S_2 O_2 + 5 HO = 125$.

This salt has been used largely in photography for some years, but its use has had so much to do with the fading of photographs, that it has now become very desirable to find a substitute for it. Its uses in fixing and toning are discussed in the articles treating of the various processes, and we shall therefore, in the present, merely describe its mode of manufacture, and principal properties.

Take of crystallized carbonate of soda 8 parts, rain water 16 parts, sublimed sulphur 1 part. Mix the ingredients, and pass through the mixture sulphurous acid gas. As soon as this acid is in excess, the liquid contains hyposulphite of soda in solution. Boil it gently for some minutes, filter it, and then evaporate it to one third of its bulk, and place it in a cool place to crystallize. The crystals are four-sided prisms.

Hyposulphite of soda deliquesces in the air. Its taste is bitter and nauseous. When heated it fuses, deflagrates, and takes fire, burning with a yellow flame. It is insoluble in alcohol, which precipitates it from its aqueous solution. It is a ready solvent of the haloid salts of silver, and this, its principal use in photography, was first suggested by Sir John Herschel. It is neutral to test paper, and extremely soluble in water, with the production of cold. Large quantities of this salt are now made in the neighbourhood of Newcastle-upon-Tyne.

The addition of an acid to a solution of hyposulphite of soda renders it turbid by causing the liberation of sulphur in a state of fine division.

HYPOSULPHITES. Many of the metallic oxides combine with hyposulphurous acid and form hyposulphites, but at present none of them posses any interest in photography except those of gold and silver; *q. v.* The hyposulphites of the alkalies, and alkaline earths, mostly act in the same way as that of soda in dissolving the haloid salts of silver. Hyposulphite of lime might probably be manufactured at a cheaper rate than that of soda, and from experiments of Dr. Alfred Taylor it appears to answer as well, or even better.

HYPOSULPHUROUS ACID ; $S_2 O_2$. This acid has not been isolated. It only exists in combination.

ICE. Water solidified by cold. Ice is in general pure water, for when water freezes it rejects all saline matters and impurities; melted ice may therefore be used in photography instead of distilled water. This may sometimes be found a convenience to the photographic tourist on the continent, since ice can be obtained at the hotels of all large continental towns. The melting point of ice is 32° Faht., and 0° Centigrade. Water may be frozen by artificial cold produced by various freezing mixtures; *q. v.*

ICELAND MOSS. *Cetraria Islandica.* A lichen which grows in exposed places in Iceland, and is used by the natives as food. When boiled with water, and allowed to cool, it forms a jelly. It is sometimes used in photography instead of gelatine, which it resembles in its properties.

ICELAND SPAR. Native carbonate of lime, crystallized and pure. The crystals exhibit the phenomenon of "double refraction" (*See* "Light,") and are used in experiments on polarized light. Their form is an obtuse rhomboid of 105° 5′ and 74° 55′, according to Dr. Wollaston. They are not always transparent, but sometimes opaque, or snow white, or tinged of different hues.

ILLUMINATION. The illumination of a surface varies inversely as the square of its distance from the source of light. The same quantity of light which falls upon a certain area at a distance of 1 foot from the luminous body will be extended over 4 times that area at a distance of 2 feet, 9 times at a distance of 3 feet, 100 times at a distance of 10 feet, and so on. This is evident from the consideration of the sections of a pyramid made at distances 1, 2, 3,—10 from the vertex. Hence the rule stated above.

IMAGE. A term used in optics to denote an assemblage or system of foci. When the foci are "real" the image is "real," and when "virtual," "virtual," (*See* "Focus.") The image formed by the lens of a camera obscura is a "real" image, and it illuminates a screen placed to receive it; the image formed by a looking-glass is not a real but a virtual image. In the former case the rays actually pass through the image, in the latter it is only the directions of the rays produced backwards which pass through the image.

In optics a luminous body is considered to be an assemblage of luminous points, from each of which a pencil of light proceeds, these pencils not interfering with one another. Each pencil being then refracted through a convex lens, its rays are brought to a focus. This focus is sometimes called the image of the luminous point which emits the rays that are collected in it, and the assemblage of all these foci constitutes the image of the object.

The distinctness of the image will depend upon the accuracy with which the rays of each particular pencil are brought to a focus.

Since the objects are in general at different distances from the lens, the image does not necessarily lie upon a plane or upon any regular curved surface.

IMPERIAL MEASURE. *See* "Tables of Weights and Measures."

IMPONDERABLE AGENTS. Light, Heat, and the various forms of Electricity are called "imponderable agents," because they cannot be weighed. When the philosopher is called on to give a definition of matter, he replies, "Matter is whatever can be proved to possess weight, that is, to be subject to the law of gravitation." Light and Heat are probably the undulations of a medium so subtle that it has not yet been weighed; and neither light, heat, nor electricity perceptibly affect the weight of bodies that are affected by them; hence they are called imponderable or immaterial agents; the terms "imponderable" and "immaterial" being strictly synonymous, according to the definition of matter.

It is probable that light, heat, and the various forms of electricity may all be undulations of an elastic medium pervading space, which, although its weight may not be appreciable by our senses aided by any form of apparatus, may still possess weight, and be material. This subtle but material ether may be supposed to fill the interstices between the atoms of bodies, and by its motions to disturb their relative positions in such a way as to produce the phenomena due to what are called the "imponderable agents." The difference between light, heat, and electricity would depend, according to this hypothesis, upon the kind and length of the undulation, and the velocity of its propagation; so that these agents may actually glide one into the other, and become merely modified cases of one form of matter in motion. But these are speculations; let them not be confounded with ascertained facts. Still, speculation is a necessary part of philosophic enquiry; and as for the undulatory theory of light, that is now received by scientific men with the same faith as the law of universal gravitation. Both hypotheses rest upon equally strong evidence, and there is the highest degree of moral certainty of their truth.

**Incidence, Angle of.** When a ray of light is incident upon the surface of any medium, the angle which it makes with the normal to the surface at the point of incidence is called the "angle of incidence."

**Incorrodible Ink**, used for writing the lables of bottles containing strong acids or alkalis :—Dissolve one part of asphaltum in two parts of oil of turpentine.

**Indian Ink.** Pure indian ink is manufactured in China. A very good imitation may be made in the following manner :—

Grind together lamp black, (previously purified with caustic potass,) and gelatine, the gelatinizing power of which has been partly destroyed by long continued boiling. It may then be scented with musk and a little camphor, and made into sticks.

Indian ink is used in photography for blackening the skies of collodion and paper negatives. It may be made extemporaneously by blackening the inside of a plate over the flame of a candle, and mixing up the lamp black thus obtained with a little gelatine water.

**Indian Rubber.** *See* "Caoutchouc."

**Indigo.** This valuable dye and pigment is of vegetable origin, and comes principally from India, being manufactured from the leaves and stems of the indigo plant. There are also West Indian, Egyptian, and Arabian varieties. Indigo is also obtained from woad.

The seeds of the plant are sown in the spring, and the plant is cut as it comes into blossom. Sometimes the indigo is obtained from the fermentation of the fresh leaves and stems, at other times from the dried leaves. An infusion is made which after fermentation is of a yellowish or greenish colour. It is then decanted and beaten with sticks for some time, which expels the carbonic acid from the liquid, and brings the particles of indigo into contact with the oxygen of the air; they then separate in grains and fall to the bottom of the vessel, the liquid becoming clear.

Indigo is a dark blue powder, devoid of taste or smell, insoluble in water, cold alcohol, ether, hydrochloric acid, and fat oils, but soluble in *strong* sulphuric acid, and creasote. The commercial sample contains scarcely one half of pure indigo, the remainder being composed of resinous substances, silica, alumina, oxide of iron, carbonate of lime, &c.

When indigo is placed in contact with a substance having a strong affinity for oxygen, it parts with oxygen and takes hydrogen, becoming hydruretted and losing its colour, and forming white indigo, (indigotine) by exposure to air and heat. This again absorbs oxygen, and acquires its former blue colour. White indigo is soluble in alcohol and ether, and is very unstable. Although, therefore, many substances may deprive indigo of its colour, yet it has always a tendency to recover it by becoming again oxidized.

Indigo dissolved in strong sulphuric acid forms a deep blue liquid, called sulphate of indigo.

Indigo is likely to prove a valuable substance in the photographic process of printing in pigments.

INFLEXION OF LIGHT. *See* "Light."

INK. Common black writing ink is tannate of iron. It is made thus:

| | | |
|---|---|---|
| Take | Bruised nut-galls . . . . | 12 parts |
| | Sulphate of iron . . . . . | 4 „ |
| | Gum arabic . . . . . | 4 „ |
| | Water . . . . . | 120 „ |

Mix together in a stone bottle, and let them stand for two or three weeks, shaking the bottle from time to time. Then, pour off the clear liquor, and add a little creasote to prevent mouldiness.

If an ounce of treacle be added to a pint of common black writing ink, the writing may be transferred by means of a copying machine.

INDELIBLE INK. Berzelius's indelible ink is made by adding a weak solution of vanadate of ammonia to an infusion of galls. A very small quantity of the salt will produce a perfectly black ink.

INK-PRINTING PROCESS. By this process positive prints may be obtained in common writing ink.

The paper is first immersed in a nearly saturated solution of bichromate of potass, and dried in the dark. It is of a bright yellow colour.

It is then exposed to light under the negative in the pressure frame, until all the details of the picture are brought out. The time required is less than that in ordinary sun-printing. The picture is of a pale brown tint upon a yellow ground.

The picture is then washed in water, in order to remove the whole of the undecomposed chromium salt. The water should be changed several times, and the print left to soak in it for two or three hours. This should be done in the dark room.

When the print has been sufficiently washed it may be taken into the light, and the picture, which is now a pale brown upon a white ground, is permanently fixed, the dark material being an oxide of chromium in combination with the lignin of the paper.

It now remains to colour the print black or purple. This is done by causing writing ink to adhere to the dark parts of the picture, which act as a mordant.

Immerse the print for a few minutes in a weak solution of protosulphate of iron, say 5 grains to the ounce of water. Then remove it, and wash it as before in several changes of water, and let it soak for two or three hours in water. The iron salt adheres to the image or mordant, but in much less quantity to the bare lignin of the paper.

Next, immerse it in a solution of tannic acid, of moderate strength. The dark parts of the picture are rapidly blackened by the formation of tannate of iron, or writing ink; the lights remaining unchanged. When fully developed wash the print well in water, and dry it. It is now finished.

The difficulties of the process consist in thoroughly removing the chromium and iron salts from the paper, so as to preserve the purity of the whites; and also in obtaining blacks of sufficient depth and vigour. The prints are permanent, and uniform in colour, and the detail very good; the process is also very economical. The paper may either be albumenized or gelatinized by mixing albumen or gelatine with the bichromate of potass. These organic substances are fixed and rendered insoluble by the reduction of the chromium, and are washed out from the parts where light has not acted. The details of the picture are therefore glazed upon a dead ground of white paper. The most vigorous prints are obtained upon unsized paper, but this is very liable to get torn in the operations of washing.

INSOLATION. Exposure to sunshine.

INSTANTANEOUS PICTURES. Photographs obtained in a fractional part of a second of time are said to be instantaneous. There is no particular process more sensitive than any in common use by which instantaneous pictures may be taken. Either the ordinary collodion process in its most efficient working state, or the daguerreotype process, is employed for this class of pictures. The instantaneity of the exposure is got by increasing the intensity of light in the image by using a lens with large aperture, which must, of course, be provided with the means of opening and shutting it instantaneously. For this latter purpose many different plans have have been suggested. It is evident that the space to be uncovered and closed should be the *smallest* through which all the light passes; hence the absurdity of spring shutters for the dark slide, for the picture is the *largest* space on which light is incident. The proper place for the instantaneous cap, as it is called, is in front of the front lens.

According to some recent experiments of Professor Zautedeschi, of Padua, it appears that the presence of the atmosphere in contact with the sensitive collodion film retards the action of light, and that sensitive iodide of silver is darkened much more rapidly "in vacuo." It seems probable, therefore, that the chemistry of the process remaining the same a shorter exposure might suffice if the camera could be exhausted of air after the insertion of the plate. This experiment might be tried without any great difficulty or expense, and, if successful, it would be a great step in photography. It seems probable enough that a quantity of air entangled with the other chemicals in the sensitive film might interfere with their mutual reactions under the influence of light, while the atmospheric pressure of 15lbs to every square inch of film might render it more compact and less sensitive. Besides, should any gas be given off during the decomposition of any of the chemicals by light, this would readily escape and diffuse itself in vacuo, instead of remaining to interfere with farther decomposition. Both theory and experiment seem, therefore, to be in favour of exhausting the camera of air in the instantaneous processes.

INVISIBLE RAYS OF THE SPECTRUM. The invisible rays beyond the extreme violet are, for a certain distance, actinic, and darken sensitive paper. These rays are the most refrangible, and the undulations are the shortest. They may be rendered visible by being passed into a solution of sulphate of quinine. (*See* "Fluorescence.") The invisible rays of the spectrum beyond the extreme red are, for a certain distance, calorific, and their existence may be proved by the heat which they produce. These rays are the least refrangible, and the undulations have the greatest length. It is probable that both the rays of maximum actinic and calorific power, lie within the limits of the visible spectrum; but this will depend upon the nature of the substance acted on.

INTERFERENCE. *See* "Light."

IODATES. Salts of iodic acid; *q. v.*

**IODATE OF AMMONIA.** $NH_3, IO_5, HO$. This salt is obtained by saturating iodic acid with ammonia. It forms small crystals sparingly soluble in water.

**IODATE OF POTASS.** $KO, IO_5$. This salt is cne of the products of the action of iodine on solution of potass. It is insoluble in alcohol S. G. 810, and requires 14 parts of water at 60° for its solution; but is more soluble in a solution of iodide of potassium. It crystallizes in small cubes. When heated it gives off oxygen and is converted into iodide of potassium. It is permanent in the air.

**IODATE OF SILVER.** $Ag. O, IO_5$. This salt is precipitated as a white powder when iodate of potass is added to nitrate of silver. It is very soluble in liquor ammoniæ,and is deposited from this solution in small rectangular prisms which retain no ammonia. It is not sensitive to light.

**IODIC ACID.** $IO_5$. This acid cannot be obtained by the direct action of oxygen upon iodine, but may be produced by the action of sulphuric acid upon iodate of soda. It combines with water and acts powerfully upon the metals, forming salts which are reduced to iodides by the action of heat.

**IODIDES.** Salts formed by the combination of iodine with a metal, or other element.

**IODIDE OF AMMONIUM.** $NH_4I=144$. This salt is made thus:—Add iodine to a strong solution of hydrosulphate of ammonia, until it begins to be coloured with iodine. On first adding the iodine a dense deposit of sulphur occurs. The solution is now acid to test-paper, from the presence of a little hydriodic acid. Neutralize this carefully with ammonia, and then filter, evaporate, and crystallize. The crystals are colourless cubes, very deliquescent, and unstable in the air. They should be dried and preserved in glass tubes hermetically sealed.

Iodide of ammonium is extremely soluble both in water and alcohol; but its alcoholic solution becomes discoloured by time, and when exposed to sunshine this change proceeds with great rapidity, the solution becoming at the same time alkaline.

Iodide of ammonium should not be used as an iodizer for negative collodion, on account of its great instability, by which free iodine is liberated and transferred to the bath, and also because nitrate of ammonia is produced in the bath, which is a salt that ought not to exist in a negative bath because of its instability and property of dissolving oxide of silver. Iodide of ammonium may however be used as an iodizer of positive collodion, because in that case the nitrate bath *ought* to be acidified with free nitric acid, which is produced by the introduction of free iodine into it.

The common impurities of iodide of ammonium are sulphate of ammonia, which is nearly insoluble in alcohol, and carbonate of ammonia. The latter renders the collodion and nitrate bath alkaline.

IODIDE OF CADMIUM. Cd. I=182. This salt is obtained by heating filings of cadmium with iodine, or mixing them in a moist state. It crystallizes in large white six-sided tables, of a pearly lustre, which are fusible, and decomposed at a high temperature.

Iodide of cadmium is very soluble in water and alcohol. When pure its alcoholic solution is permanent, and becomes discoloured very slowly and slightly by exposure to sunshine. Collodion iodized with iodide of cadmium does not become discoloured or undergo any visible alteration by time, if kept in a cool dark place. This is a great advantage, but, on the other hand, the nitrate of cadmium formed in the N. S. bath is a salt which has an acid reaction and its effects are similar to those produced by free nitric acid. The nitrate bath therefore gets gradually out of order when this iodizer is employed. The permanence of collodion iodized with iodide of cadmium is probably due to the difficulty with which cadmium is oxidized.

The common impurity of iodide of cadmium is iodide of zinc. When this is present the collodion becomes gradually discoloured; zinc being an easily oxidizable metal.

Iodide of cadmium impairs the fluidity of collodion.

IODIDE OF CALCIUM. Ca. I=146. This salt is obtained by dissolving carbonate of lime in hydriodic acid, evaporating to dryness, and fusing the residue in a close vessel. When this is dissolved in water and evaporated, it furnishes white deliquescent crystals.

The nitrate of lime formed in the nitrate bath when this iodizer is employed is a very deliquescent salt, and would therefore tend to preserve the moisture of the excited film. The deliquescent properties of the iodide and nitrate of lime recommend this iodizer for use, although it is not much employed.

Iodide of calcium is extremely soluble in water, and alcohol, even when absolute. The alcoholic solution is discoloured by light, and collodion iodized with it becomes gradually reddened, as with the potassium salt. It gives excellent negatives, remarkable for their cleanness and density.

IODIDE OF IRON. There are two iodides of iron, viz. a protiodide Fe. I, and a periodide, the exact composition of which has not been ascertained.

Protiodide of iron is formed by digesting iron filings or iron wire in water with iodine, the metal being in excess. A greenish solution is obtained, to which sugar is sometimes added for medicinal purposes. It is extremely unstable, and throws down oxide of iron by exposure to air. On evaporation it yields a grey fusible salt, which is soluble in alcohol, the solution being rapidly decomposed by light.

When protiodide of iron is used as an iodizer in photography, protonitrate of iron is formed in the nitrate bath, and also in the sensitive film. This acts as a developer, and speedily blackens and spoils the bath; it also developes the image so long as the plate or paper continues moist; the picture, therefore, comes out after exposure, by a sort of self-developing process. In consequence of this property of iodide of iron as an iodizer, it has been thought to give extraordinary sensitiveness to collodion, but that opinion is erroneous.

IODIDE OF MAGNESIUM. Mg. I=138. When carbonate of magnesia is added to a saturated alcoholic solution of iodide of potassium, double decomposition occurs; iodide of magnesium is formed and held in solution, and insoluble carbonate of potass precipitated. When the solution is filtered, it may be used as an iodizer for collodion. In its properties it resembles iodide of calcium, the nitrate of magnesia formed in the nitrate bath being deliquescent, and having a slightly acid reaction. This iodizer has been pronounced by some operators a very good one, particularly in hot weather.

IODIDE OF POTASSIUM; KI=165.

Iodine and potassium unite energetically, giving out heat and light; and potassium burns in the vapour of iodine. The result of this combination is the white anhydrous salt—iodide of potassium. The mode of producing this salt commercially is to add iodine to a solution of potass, until it assumes a brown colour; then evaporate to dryness, add a little charcoal, and fuse the residue at a red heat, which decomposes any iodate of potass that may be formed; dissolve, filter, and recrystallize the salt.

Sometimes iodide of potassium is made by passing sulphuretted hydrogen through a brown mixture of liquor potassæ and iodine, till it becomes colourless; expelling any excess of sulphuretted hydrogen by heat, filtering, neutralizing with potass, and crystallizing. Another way is, to decompose either iodide of zinc or iodide of iron by carbonate of potass.

Iodide of potassium crystallizes both in cubes and prisms. The crystals are anhydrous, and very slightly deliquescent in damp air. They are extremely soluble in water, 100 parts of which dissolve at 65° 143 parts of the salt, with production of cold; but much less soluble in alcohol; absolute alcohol S. G. 794, dissolving about 8 grains to the ounce; S. G. 823, about 25 grains; S. G. 835, about 60 grains.

The impurities contained in commercial iodide of potassium are iodate of potass, carbonate of potass, sulphate of potass, chloride of potassium, and sometimes of zinc, and iron.

Iodate of potass may be detected by adding a little tartaric acid to the solution, and also a little starch. If iodate be present the tartaric acid decomposes it, and the liberated iodine forms purple iodide of starch. Fusion, at a red heat, decomposes iodate into iodide.

Carbonate and sulphate of potass are detected by adding chloride of barium to the solution, which throws down white insoluble carbonate, or sulphate of baryta. Another test for carbonate of potass is to expose the alcoholic solution of the iodide to sunshine; if it soon becomes slightly discoloured it is pure, if not, it contains carbonate. The presence of much carbonate of potass renders iodide of potassium highly deliquescent.

Aqueous solution of iodide of potassium is immediately discoloured by the addition of chlorine water, or nitric acid, but not by the weaker acids in the dark; in the light the discoloration proceeds more rapidly.

This salt is much used as the iodizer for the negative processes on collodion or waxed paper. The white spots sometimes seen in negatives, and which are square when viewed in the microscope, are supposed to be due to undecomposed crystals of iodide of potassium. These peculiar spots do not occur with other iodizers. No iodide produces a more sensitive collodion than iodide of potassium, and it is on the whole a very good one to employ. The alcoholic solution is stable in the dark, but collodion iodized with it becomes gradually reddened by time, and rendered insensitive.

IODIDE OF SILVER. Ag. I = 234. Iodine and silver are supposed to combine directly and produce iodide of silver, for if a silver plate be placed in a bottle containing iodine and left for a short time, it is tarnished with a yellow film supposed to be iodide of silver. If this experiment be made in the dark, and the tarnished plate exposed to light, either under a negative or in a camera obscura, and then submitted to the fumes of mercury, an image is developed, which proves that silver tarnished with iodine is sensitive to light. The yellow substance which forms the tarnish on the metal may not, however, be pure iodide of silver, and there are other reasons for supposing that pure iodide of silver is *not* sensitive to light.

Iodide of silver may be obtained by double decomposition, by adding a solution of nitrate of silver to a solution of an alkaline or metallic iodide, such as iodide of potassium or cadmium. The oxygen of the oxide of silver in the nitrate goes to the metal and forms potass or oxide of cadmium; this is converted into nitrate of potass or cadmium by the nitric acid, which leaves the silver, and the iodine combines with the silver to form iodide of silver, which is a yellow insoluble amorphous substance. When the nitrate of silver is in excess the precipitate is of a strong yellow colour, and is darkened very quickly to a pale brown tint by exposure to light; but when the iodide of potassium is in excess the colour of the precipitate is rather paler, and it is then absolutely insensitive to light. These results are the same however thoroughly the precipitate may be washed in water, frequently changed, before exposing it to light. For the same reason it happens that an excited collodion film or waxed paper never entirely loses its sensitiveness by washing, because the iodide of silver was formed from a solution containing nitrate of silver in excess; but an iodized calotype paper, prepared with double iodide, in which iodide of potassium is in excess, appears to be absolutely insensitive to light, at least so far as the power of developing a picture upon it by the ordinary developers is concerned. Iodide of silver, with nitrate of silver in excess, is the most sensitive to light of all compounds at present known, and is therefore used in the negative processes of photography. It is darkened more rapidly in vacuo than in air, and is also darkened to a coffee colour by being boiled for some minutes with distilled water. When iodide of silver is obtained by double decomposition in the manner described, with nitrate of silver in excess, the nitrate of the alkali or metal also formed in the solution, and from which the precipitated iodide of silver is not thoroughly cleared, affects to some extent the properties of the iodide; for instance, when nitrate of potass remains, which is a neutral salt, the iodide is more quickly darkened than when nitrate of cadmium, which is an acid salt, remains.

Iodide of silver is insoluble in water and alcohol, and nearly insoluble in ammonia. It is soluble in concentrated solutions of the alkaline chlorides, bromides, and iodides, and also in hyposulphite of soda, and cyanide of potassium, forming in every case a soluble double salt of silver and the alkali. Concentrated nitric and sulphuric acids also decompose it. It may be reduced by metallic zinc, forming soluble iodide of zinc, and metallic silver as a black powder. When iodide of silver is fused at a red heat it acquires a red colour. It volatilizes before the blow-pipe, leaving a little silver only behind.

When iodide of silver is dissolved in concentrated solutions of an alkaline iodide, bromide, or chloride, the double salt formed is only soluble in the quantity of water used; if more be added the solution immediately becomes milky. This effect does not happen when either hypo-sulphite of soda or cyanide of potassium is used as the solvent.

IODIDE OF STARCH. Iodine combines with starch, and forms a purple compound. Starch is generally used as the test for free iodine. When paper containing starch is immersed in a solution of iodide of potassium it speedily assumes a purple tint, the strength of which depends upon the quantity of starch present in the paper. Also, wherever nuclei of starch exist deep purple spots are produced. Papers which have been bleached with chlorine are also reddened by a solution of iodide of potassium.

IODIDE OF ZINC; $\mathrm{Zn.\ I} = 158{\cdot}6$. Zinc and iodine have a very strong mutual affinity. When iodine is added to a mixture of zinc filings and water, until it becomes slightly brown, and a gentle heat applied, iodide of zinc is produced. On evaporating the solution to dryness in a retort the iodide is fused, and at a higher temperature volatilized; it condenses in prismatic crystals.

The aqueous solution of this iodide is very unstable in the air; oxide of zinc being formed and free iodine liberated. Both the iodide and nitrate of zinc are deliquescent. This iodizer is sometimes used in photography, but its instability is an objection to it. It is not always free from iodide of iron, which discolours and spoils the nitrate bath.

IODINE, (Greek ιωδης violet coloured,) $\mathrm{I} = 126$. This elementary substance is contained in minute quantity in sea water, and some mineral springs, but enters more largely into the composition of certain sea weeds, chiefly found on the western coasts of Ireland and Scotland; a minute trace has also been found in cod liver oil, and in the yellow sap of the "*Indus fetedissimus.*"

Iodine is chiefly manufactured in Glasgow, from kelp. (*See* "Kelp.") This is lixiviated in cold water, and the solution gradually evaporated, when the various salts which it contains, and which are less soluble than the iodides, crystallize and are removed in succession. The dark mother liquor which remains contains the iodides. From these the iodine is separated by distilling the liquid with sulphuric acid and black oxide of manganese. The iodine passes over as a violet coloured vapour which condenses in the alembic and neck of the retort in long pointed crystals of a dark colour, opaque, and having a metallic lustre. These are washed out with a little water, and dried with blotting paper. The process is minutely described in Dr. Graham's Elements of Chemistry.

Iodine is sparingly soluble in water, but dissolves readily in alcohol and ether. The commercial sample may be purified by disssolving it in alcohol and precipitating it with water. The impurities, or adulterations, are principally plumbago, sulphide of antimony, and black oxide of manganese, all of which are insoluble in alcohol. Iodine is dissolved by solutions of the alkaline iodides.

Iodine is extremely volatile when moist. At 120° it rises rapidly into vapour, at 220° fuses, and at 350° boils and produces dense violet coloured fumes which crystallize in brilliant plates and acute octohedra. The aqueous solution of iodine does not evolve oxygen when exposed to sunshine, nor has it bleaching properties.

**IODO-NITRATE OF SILVER**; $Ag.O, NO_5 + Ag.I$. A boiling saturated solution of nitrate of silver will dissolve a small quantity of iodide of silver, and, on cooling, crystals are formed of a double salt which has been called Iodo-nitrate of silver. This salt is also formed when an excited collodion plate or waxed paper is allowed to dry spontaneously, without having been previously washed. In this case the free nitrate on the film or paper becomes concentrated by the evaporation of the water, and is then able to dissolve the iodide of silver, and form a double salt.

In the latter case, the iodo-nitrate of silver is not decomposed by water and iodide of silver precipitated, nor is it blackened by light, but on the contrary appears to be perfectly insensitive to light. Nevertheless it has been affirmed by Dr. Schnauss that the opposite results are obtained in the former case. An old nitrate bath saturated with iodide of silver is certainly rendered turbid by the addition of water. These matters require further investigation.

**IODURETTED IODIDES.** *See* "Hydriodous Acid."

**IRON.** Fe.=28. This useful metal may be said to occur everywhere in combination of some kind. Many of its salts are of use in photography; these are the chlorides, sulphates, nitrates, iodide, acetate, citrate, and oxalate; *q. v.*

A surface of polished iron is not oxidized in dry air, nor in distilled water which has been freed from air by boiling, but in damp air it is oxidized or rusts very rapidly. This is prevented by the addition of an alkali, as lime, or potass, to the water, and iron will then retain its lustre under water for years; but acids and neutral salts have an opposite tendency. The reason of this is very obscure. By the contact of zinc, iron is protected from all common sources of oxidizement and corrosion; hence the value of the process by which iron is "galvanized," or coated with zinc by being immersed in melted zinc.

The tests for iron are prussiate of potass, red or yellow, which give a blue precipitate, and infusion of galls which gives a black colour to the solution,

**IRON, OXIDE OF.** There are four definite oxides of iron viz:—

The Protoxide . . . $Fe.\ O$
Sesquioxide. . . $Fe._2\ O_3$
Black oxide . . $Fe._3\ O_4$
Ferric acid . . . $Fe._1\ O_3$.

The salts of the sesquioxide of iron are in general converted into salts of the protoxide by the action of light; and, conversely, the salts of the protoxide act as developers by acquiring oxygen, and becoming converted into persalts. The solutions of these salts are generally unstable in the air, and become oxidized. The most important of them is the proto-sulphate.

Hydrated protoxide of iron is a white precipitate formed by adding caustic potass to a solution of a pure proto salt. When washed and dried it assumes a greenish colour, and is very readily oxidized, becoming dark-green or brown.

Sesquioxide, or peroxide, occurs native as hæmatite, (a hydrate,) and also in beautiful crystals, as specular iron ore, in the island of Elba. It may be produced by adding ammonia to perchloride of iron and washing, drying, and igniting the precipitated hydrate. This oxide is red, and forms the pigment called "Venetian Red." Iron rust is the sesquioxide of the metal. It forms salts which have an acid reaction, and are decomposed by light. They are generally of a brown colour.

Black oxide of iron, or magnetic oxide, is a compound of the protoxide and sesquioxide. It is a natural product, occurring in regular octohedral crystals, and is incapable of forming proper salts. The black scales of iron picked up in a blacksmith's forge approach black oxide in composition. The loadstone is black oxide of iron.

Ferric acid is produced by heating to full redness, for an hour, in a covered crucible, a mixture of one part of sesquioxide of iron, and four parts of dry nitre. This forms an unstable amethystine coloured salt, which is ferrate of potass. When added to a salt of baryta, permanent ferrate of baryta is produced, which is of a crimson colour, and insoluble.

**ISINGLASS.** Fish glue; a pure form of gelatine. It is soluble in boiling water, and gelatinizes on cooling; and also soluble in weak acids, but is precipitated by the addition of an alkali. Isinglass is obtained from the air bladders of sturgeons, and principally from the great sturgeon found in the Caspian Sea. It is manufactured chiefly at Astracan, and is bleached by the fumes of burning sulphur. The process of manufacture consists in first steeping the bladders in water, then removing the outer skin, putting them into a hempen bag, squeezing them, softening them between the hands, and twisting them into small cylinders, which are afterwards bent into the shape of a lyre.

**ISOMERISM.** (Greek *ισος* equal, *μερος* a part.) There are numerous instances in chemistry in which two bodies are identical in composition, but different in appearance and properties. Such bodies are said to be "isomeric."

For instance, cyanogen, which is a gas, is represented by the formula $C_2$ N, while paracyanogen, which is a black solid having different properties, has also the formula $C_2$ N.

The difference in properties between isomeric substances is supposed to proceed from a difference of arrangement of their atoms.

**ISOMORPHISM.** (Greek *ισος* equal, *μορφη* form.) There are many instances in chemistry in which similarity of properties is possessed by bodies, or classes of bodies, having the same form. This is remarkably shewn in the case of the chlorides, iodides, and bromides, which are "isomorphous;" the term being applied to bodies which can replace each other in combination, without producing any essential difference in the crystalline form of the compound. Bodies may therefore be classed in isomorphous groups, the individuals of which possess, in many respects, similar properties.

**IVORY.** Ivory is the osseous matter of the tusks and teeth of the elephant, hippopotamus, wild boar, several species of seal, and the horn of the sea-unicorn. The latter furnishes the best ivory.

The composition of ivory is the same as that of the teeth of animals, viz. 3 parts phosphate of lime, and a little carbonate, with 1 part cartilage.

Photographs may be taken upon plates of polished ivory, and they have remarkable beauty and delicacy.

Ivory is liable to turn yellow by time. Its whiteness may be restored by moistening and rubbing it with pumice stone, and exposing it to sunshine while moist, under a glass shade, carefully sealed to the stand at the bottom, in order to retain the moisture and prevent the ivory from cracking.

Collodion positives may be taken upon dyed ivory. It may be dyed black by boiling it first in a decoction of logwood, and then in a solution of red acetate of iron; or violet, by first boiling it for a short time with proto-chloride of tin, and then in logwood. The sheets should be dyed first, and polished afterwards.

IVORY, ARTIFICIAL. This has been made for photographic purposes by mixing sulphate of baryta with albumen, and rolling it into sheets.

Pinson's artificial ivory, much used in France, is made by immersing a sheet of gelatine in alumina dissolved in acetic acid. The two combine, and when the gelatine has imbibed sufficient of the alumina, it is taken out, hung up to dry, and finally polished.

Artificial ivory may also be made by mixing ivory dust with albumen, and rolling the paste into sheets, then drying and polishing them.

IVORY, FLEXIBLE. Ivory articles may be rendered flexible and semi-transparent by immersing them in a solution of pure phosphoric acid, S. G. 1·130, and leaving them till they lose their opacity. They are then washed with water, and dried, when they become as flexible as leather. They are hardened on exposure to dry air, but resume their flexibility on being immersed in hot water.

IVORY, VEGETABLE. The milk of the fruit of the ***Phytelephas mucrocarpa*** which grows in Central America, hardens and becomes like ivory. It is frequently used as a substitute for ivory in buttons and small turned articles.

IVORY BLACK. Ivory dust carefully calcined in a closed crucible.

**Japan.** Black japan for leather is made thus:—

1st Method.

| | | |
|---|---|---|
| Mix | Boiled linseed oil | 1 gallon. |
| | Burnt umber | 8 ozs. |
| | Asphaltum | 3 ozs. |

Boil together, and add sufficient oil of turpentine to give it the proper consistence.

2nd Method.

| | | |
|---|---|---|
| Mix | Oil of turpentine | 2 ozs. |
| | Shellac | 1 dram. |
| | Alcohol | 4 ozs. |
| | Lamp black | ½ oz. |

**Jew's Pitch.** Bitumen Judaicus: Asphaltum; *q. v.*

**Jeweller's Plate Powder.** *See* "Rouge."

**Jeweller's Putty.** Tin putty, an oxide of tin, made by levigating the crusts of oxide that form upon the metal when kept for some time in fusion. It is used for polishing hard bodies.

**Juices of Plants.** Papers stained with the juices of various plants are altered in colour by exposure to sunshine. Sir John Herschel, some years ago, communicated to the Royal Society the results of many interesting experiments made by him on the juices of plants. His method of proceeding was, to crush the petals of the flower to a pulp in a marble mortar, either alone, or with the addition of alcohol, and to express the juice by squeezing the pulp in a linen cloth; it was then spread upon paper with a flat brush, and allowed to dry spontaneously in the dark. The tint communicated to the paper is not always that of the petal of the flower. The most sensitive colour met with was that of the *Corchosus Japonica*, the yellow tint of which is speedily bleached by sunshine. Paper stained with the blue tincture of the double purple groundsel is completely bleached by light. The juice of the *Senecio splendidus* imparts a rich and deep velvety purple tint to paper, which is very insensitive to light.

We may add that the juice of the *Rhus striata*, of South America, and of the *Rhus venenata*, or poison tree, of North America, both communicate indelible black stains to paper. The latter has been used for marking linen.

Among the juices of plants are many important dyes, such as indigo, madder, saffron, &c., &c., many of which are bleached more or less by light. In the case of indigo, however, the expressed juice from the leaf of the indigo plant is originally colourless, but is darkened to a deep purple tint by exposure to air and light. This dye is very permanent.

Kaolin. Porcelain clay, used for decolorizing discolored nitrate baths, and other solutions. The best way of using it is to add a little to the solution, shake well up together several times, and then let it stand to settle; afterwards decant the clear liquid.

Kaolin is a fine pure white clay prepared by levigation from mouldering granite, and used for making vessels of porcelain. It contains nearly equal parts of alumina, or pure clay, and silica, together with about one per cent. of lime and oxide of iron. It is found in veins in primitive mountain districts, chiefly in China and Japan, Saxony, the neighbourhoods of Limoges and Bayonne in France, and in England in the counties of Devon and Cornwall. We have also found it in Jersey.

Kata-Positive. A positive intended to be viewed by *reflected* light, that is, to be looked *at*, may for convenience be called a kata-positive, in contradistinction to a "dia-positive," which is intended to be looked *through*, or viewed by *transmitted* light. The adoption of these terms would, in many cases, prevent confusion. *See* "Dia-positive."

Kelp. British barilla: the cinder ash obtained by burning various species of sea-weed, but chiefly the *Fucus vesiculosus*, or "bladder-wrack," and the *Fucus nodosus*, found on the western coasts of Ireland and Scotland. It is the principal source of iodine, and contains chiefly soda salts. Pearlash, or wood-ashes, contains principally salts of potass. Soda was formerly obtained from kelp, and the manufacture of this substance was then extensively carried on by the inhabitants of the west coast of Scotland; but since the method of obtaining soda from common salt has been introduced the manufacture of kelp has greatly declined.

Kreosote, Creasote. (Greek, κρεας flesh, σωζω to save.) This substance is obtained from the distillation of wood tar, by a troublesome process which need not be described in this work. It is a colourless, transparent liquid, of great refractive and dispersive power, having a caustic taste, and a strong odour resembling that of smoked meat. It combines readily with acetic acid and ammonia; and alcohol, ether, naphtha, and acetic ether dissolve it in all proportions. It dissolves many salts, also the resins, camphor, essential oils, and almost all vegetable colouring matters, and coagulates albumen and casein. It mixes sparingly with water.

The chief use of kreosote is derived from its powerful antiseptic properties. It prevents the putrefaction of animal and vegetable matters, and a drop or two may sometimes be added with advantage to solutions of gelatine, iodizing solutions for waxed paper, ink, &c., &c. A substance similar to kreosote is supposed to have been used by the ancient Egyptians for the purpose of embalming mummies.

**Lac.** A species of resin secreted from the puncture made by an insect called the *Coccus ficus*, in the branches of various plants which grow in the East Indies.

Lac is a very important article in manufactures, because not only is the resin useful for making varnishes, sealing wax, &c., but the colouring matter combined with it forms a magnificent red dye, which is extensively used as a substitute for cochineal. In consequence of the puncture of the insect, the twig of the plant becomes encrusted with a red resinous substance, sometimes as much as a quarter of an inch thick. These encrusted twigs are called "stick-lac." It contains about 7 per cent. of resin, and one-twentieth part of that quantity of colouring matter. This valuable colouring matter is removed by pulverizing the stick-lac, and triturating it with water. What remains is called "seed-lac." In India this is put into oblong bags of cotton stuff, and a man at each end of the bag holds it over a charcoal fire. The liquefied resin drops through, and is received upon smooth stems of the banyan tree; in this way it is formed in thin plates, and is called "shell-lac."

Shell-lac consists of two or more resins, one of which is soluble in all proportions in anhydrous alcohol, ether, and volatile and fat oils. The alcoholic solution is of a reddish colour, and forms an excellent spirit varnish in photography. (*See* "Varnish.") Shell-lac may also be easily dissolved in dilute hydrochloric and acetic acids, and also in a solution of borax, with the aid of heat. Before dissolving it in alcohol, it should be very finely pulverized and exposed to the air for some months. Shell-lac may be bleached with chlorine, and then makes colourless varnishes. The bleaching is effected by first dissolving it in caustic potass, and then passing chlorine gas through the solution, after which it is pulled and washed in hot water, and twisted into sticks.

Shell-lac is much used in making sealing wax; *q. v.*

Lac dye is made by evaporating to dryness the liquid in which the pounded crude lac is digested, and making the residue into cakes. This is soluble in dilute sulphuric or hydrochloric acid, and the mordant is protochloride of tin, and bi-tartrate of potass. It gives a fine scarlet colour.

**Lacquer.** A varnish composed chiefly of shell-lac dissolved in alcohol, and coloured with gamboge, dragon's blood, &c. The following is a good formula:—

| | | |
|---|---|---|
| Seed lac | 120 | parts |
| Gamboge | 120 | „ |
| Dragon's blood | 120 | „ |
| Saffron | 39 | „ |
| Rectified alcohol | 1000 | „ |

Digest with heat, and strain.

The following is another formula in which turpentine is the solvent:—

| | | |
|---|---|---|
| Seed lac | 120 | parts |
| Sandarach | 120 | „ |
| Dragon's blood | 15 | „ |
| Turmeric | 2 | „ |
| Gamboge | 2 | „ |
| Venice turpentine | 60 | „ |
| Spirits of turpentine | 1000 | „ |

Digest with heat, and strain.

**Lactate of Silver.** A salt of lactic acid and oxide of silver. It forms white acicular crystals, which are very soluble in water, and quickly blackened by light.

**Lactate of Soda.** A salt of lactic acid and soda, formed by decomposing acetate of soda by lactic acid. It is very soluble in water. A small quantity added to the nitrate bath produces the effects due to an organic salt of silver, viz., intensity in the blacks of the negative, and want of sensitiveness. The double decomposition of lactate of soda and nitrate of silver produces lactate of silver and nitrate of soda.

**Lactic Acid.** $C_6 H_5 O_5 + HO$. A free acid contained in sour milk; also in certain animal fluids, and sour rice-meal, wheat-paste, the juice of the beet-root, &c.

To obtain it, sour whey is evaporated to one-sixth of its volume and filtered. A little lime is added to precipitate phosphoric acid, and the excess of lime removed by oxalic acid. The liquid is then filtered and evaporated to the consistence of syrup, after which the lactic acid is extracted by means of alcohol, in which it is soluble. Pure lactic acid is then obtained from the alcoholic solution by a somewhat complicated process, which need not be described in this place.

Pure lactic acid is a colourless liquid, of the consistency of syrup, inodorous, extremely sour, deliquescent, miscible in all proportions with water and alcohol, but less soluble in ether. It forms in general soluble salts. Its S. G. is 1·215.

LAMP BLACK. A form of charcoal, obtained by burning the refuse resin left in the distillation of turpentine, and collecting the smoke in chambers hung with old sacking, upon which the soot is deposited. This is swept off from time to time, and is commercial lamp black.

When lamp black has been heated to redness, it is a very pure form of charcoal, and burns entirely away without leaving an ash. Its principal use is in the manufacture of printer's ink (*q. v.*). A black water-colour is made of it by mixing it with honey; and also Indian ink (*q. v.*). It will probably, before long, be used extensively in photography in the process of printing in carbon.

Lamp black mixed with French polish is used by opticians for blackening the brass work of optical instruments; and mixed with size for blackening woodwork. These mixtures leave no gloss when dry.

LATENT HEAT. LATENT LIGHT. It is stated in the article on Light, that both light and heat are certainly due to the undulations of an elastic ether which pervades space; and that the rays, both of light and heat are propagated with enormous velocity, and can be refracted, reflected, polarized, &c., by similar means. We have suggested, therefore, that heat may be an undulation of the same universal ether as that in which light is propagated, the difference being that the waves of heat are longer than those of light. There is however this difference between light and heat, that whereas bodies when exposed to radiant heat become heated, that is to say become themselves sources of radiant heat, bodies exposed to light do not in general become self-luminous, or sources of light; (we say *in general* because solar phosphori offer a few exceptions to the rule). This may be in consequence of the light received by bodies being converted into heat; the short waves of light which vibrate in the interstices of a body being lengthened into waves of heat by the mechanical effect of the atoms of the body vibrating amongst them.

When a body is heated it in general expands, and contracts on cooling, that is, radiates heat while returning to its former dimensions. It is in the highest degree probable that the Sun once extended far beyond the limits of the planetary system, its temperature being then very little above that of space; that it gradually contracted in dimentions, and by so doing became a source of heat and light to the planets which were from time to time detached from it; that this contraction of volume may be still going on, while the amount of light and heat propagated by the condensation of the solar materials may be for ages to come continually on the increase, after which a reaction may occur similar to what has happened in the case of the earth, which was once in a fluid incandescent state, propagating light and heat into space by its contraction of volume, which volume at last attained a minimum, the surface of the globe cooled into a solid crust, and the earth became as we find it, non-luminous and opaque.

*Matter*, then, in motion can act upon *ether* and communicate vibrations to it; on the other hand, *ether* in motion can act upon *matter* and communicate vibrations to *it*, altering its form, volume, &c. Among these actions and reactions between gross matter and subtle ether we must endeavour to seek for an explanation of the phenomena due to the imponderable agents.

When a body is heated above the temperature of surrounding objects it gradually cools until an equal temperature is obtained amongst them, in which state the atoms of ether pulsate in unison with those of the bodies.

Heated bodies do not all cool at the same rate. The time in which a body at a certain temperature cools, when suspended in vacuo, to a certain lower temperature, is called its "Specific Heat." The following table shews the specific heats of different bodies.

| | | | |
|---|---|---|---|
| Water | 1000 | Zinc | 93 |
| Sulphur | 188 | Silver | 56 |
| Glass | 117 | Mercury | 33 |
| Iron | 110 | Platinum | 31 |
| Copper | 95 | Lead | 29 |

Experiments seem to indicate that the specific heat of a body varies inversely as its atomic weight. For instance, the atomic weight of sulphur is 16, of lead 103; the specific heats of these substances being as 188 : 29; and the ratio of 29 : 188 being nearly equal to that of 16 : 103.

Now we come to the particular subject of this article, viz., "Latent Heat."

Strong brine, *i. e.* a saturated solution of common salt in water, freezes at 0° of Fahrenheit's scale; water at 32°. Suppose then that two vessels, one containing water, the other brine, and each having a thermometer immersed in the liquid marking the temperature, say at 60°, are taken out-of-doors on a winter's day, when the temperature is 20°. The thermometers at once begin to fall; that in the brine goes on continually falling until it reaches 20°, while that in the water exhibits a curious phenomenon; it first sinks gradually until the water begins to freeze, then remains stationary until the *whole* of the water is congealed or crystallized into ice, (or it may rise a little during the process,) and afterwards goes on falling as before until the temperature of the ice becomes 20°. It remains therefore to explain this curious phenomenon, which accompanies the change of form of a body from the liquid to the solid state.

It has been supposed, we think erroneously, that water contains "latent heat," that is, material atoms of heat in chemical combination with it, and that these are given off during the process of congelation. This supposition of "latent heat" is evidently only tenable on a sort of *corpuscular* theory of heat, for on the *undulatory* theory of heat "latent heat," would be synonymous with latent motion, and the idea would involve a contradiction. There cannot be latent heat on the undulatory theory, and it remains for us to offer another explanation which shall be consistent with that theory.

The facts are simply these:—During the time which is occupied by the water in changing its form from the liquid to the solid state it does not propagate any undulations of heat in the surrounding space, and thereby become colder. The propagation of undulations of heat by the action of the atoms of water upon those of the ether contained in it is for a time arrested. It is only necessary to state the fact in the above form. No further explanation is required.

Conversely: if a lump of Wenham Lake ice at a temperature of 10° be brought into a warm room, it does not begin to melt until the temperature has risen to 32°, and it remains stationary at that temperature until the *whole* of the ice is melted; the temperature of the water then begins to rise. The explanation is the same as before.

"Latent heat" may be a convenient term to employ, but the *facts* should not be misunderstood.

It would be out of place to pursue this subject further, but all the phenomena of latent heat may be explained in the way we have pointed out.

"Latent light" is another expression which has been adopted somewhat hastily in attempting to explain some phenomena of light lately discovered by M. Niépce de St. Victor. Certain substances called "Solar phosphori" have the well known property of becoming self luminous by being exposed to light; just as a piece of slate has the property of becoming hot by being held before the fire. The piece of slate when removed from the fire radiates heat;—the solar phosphorus, when removed from the sunshine and taken into a dark room, radiates light. The two cases are strictly parallel. This property of solar phosphori has been long known, but M. Niépce has discovered lately that white paper, and other substances, become *actinic*, after having been exposed to sunshine, and in this state react upon sensitive photographic tablets in the dark room. These substances have been said to absorb light by insolation, and retain it as "latent light" within their pores; but this explanation involves the same absurdity as the idea of "latent heat." The fact probably is, that the insolated substance does not convert the actinic rays into heat rays, as bodies mostly do, but propagates them unchanged, when taken into the dark, and thereby produces the effects due to actinism, when laid upon a sensitive photographic paper or plate. The experiment described by M. Niépce, in which light is supposed to be potted in a sealed cylinder, and liberated after any interval of time by removing the cover, may be explained thus:—

The inside of a hollow cylinder of tin is lined with paper which has been steeped in a solution of nitrate of uranium. It is then exposed to sunshine for some time, and sealed up. On removing the sealed cover, in the dark room, some months afterwards, and applying the open end of the cylinder to a piece of sensitive chloride paper, it is darkened all over; or if an engraving on india paper be laid upon it, so as to act as a negative placed between it and the contents of the tube, an image of the engraving is obtained. The explanation is, that the nitrate of uranium in the paper is deoxidized by light, and converted into a proto-nitrate of uranium. This becomes oxidized again in time, and converted into a per-salt, at the expense of the oxygen contained in the aqueous vapour in the tube, thereby liberating hydrogen, which darkens the chloride paper, or prints an image upon it through india paper.

To seal up *light* in a pot would be the same thing as to seal up *motion*, for light is motion. Such an idea is surely absurd.

**Lavender Rays.** The faintly luminous rays beyond the violet end of the spectrum are called "lavender rays." They are said to be highly actinic, but the maximum of actinic power lies probably within the violet rays; this, however, may depend upon the nature of the substance acted on.

**LEAD.** Pb.=104. This useful metal has been known from the earliest times, and was called by the alchemists "Saturn." It is found chiefly in the form of sulphide, or "galena." Pure lead may be obtained by heating oxalate of lead in a covered crucible. Lead may be rolled into sheets, and drawn into wire; it melts at 612°; and by the joint action of heat and air is easily oxidized, although at ordinary temperatures it undergoes but little change from exposure to air. When in a state of fine division it combines readily with oxygen, and takes fire in the air. When immersed in distilled water it takes oxygen from the air contained in the water, and the oxide formed being soluble to some extent in the water it becomes impregnated with oxide of lead. Hence arises the poisonous character of water which has been collected in a leaden cistern, or passed through leaden pipes. The most useful salts of lead in photography are the acetate, nitrate, and chloride; *q. v.*

**LEAD, OXIDES OF.** There are 5 oxides of lead, viz.: the suboxide, $Pb._2 O$; the protoxide, $Pb. O$; the red oxide, $Pb._3 O_4$; the sesquioxide, $Pb._2 O_3$; and the peroxide, $Pb. O_2$. Of these the protoxide only is salifiable. Litharge is protoxide of lead; and red lead, or "minium," the red oxide. Peroxide of lead, or plumbic acid, is deoxidized by light, and reduced to protoxide. Suboxide of lead is the grey powder formed on the surface of lead after long exposure to air.

**LEADEN PIPES, CISTERNS, &c.** When pure rain water is collected in leaden tanks, or passed through leaden pipes, the lead is oxidized by the air contained in the water, and a small quantity of the oxide formed is dissolved in the water, thereby communicating to it poisonous qualities. The same thing does not, however, happen to the same extent when river or spring waters, which contain in general certain soluble salts, are retained in leaden vessels, because then the surface of the lead soon becomes coated with an insoluble precipitate of sulphate, or carbonate, or phosphate of lead, which protects it from being further acted on by oxygen.

The presence of oxide of lead in the water used for photographic purposes may in some cases be rather beneficial than otherwise. For instance, in the pyrogallic developer, when freshly made, it would increase the energy of the development; but the developer would not keep; in a few hours, perhaps, it would become discoloured. Similarly, oxide of lead in the nitrate bath would perhaps increase the sensitiveness of the collodion film, but render the bath liable to "fog" the picture.

Lead may be easily detected in water by tests which the photographer generally has at hand. Iodide of potassium would give a yellow tinge, sulphuric acid a white cloudiness, sulphide of ammonium a dark discoloration to water containing oxide of lead in quantity sufficient to render its presence sensibly injurious, or otherwise.

Any brass work in contact with lead would set up electric action, and assist the production of oxide of lead.

Bottles should not be made of flint glass, as some chemicals act on the lead which it contains. There is no lead in crown glass, and this should always be used for bottles intended to contain chemicals.

Achromatic lenses should never be exposed to the fumes which sometimes prevail in the laboratory, or dark room. The surface of the flint lens is frequently injured from this cause, and becomes iridescent.

LEATHER. An insoluble compound of tannin and gelatine. Tannin is a very delicate test of gelatine, and if added to water containing the one five-thousandth part of gelatine it produces a cloudiness in it. It combines so energetically with gelatine, that if a piece of skin or bladder of sufficient size be suspended in a solution of tannin the whole of it is in time abstracted from the water, and the skin becomes converted into leather.

In the manufacture of leather the skins of animals are first steeped in lime water, in order that the hair and cuticle may be more easily separated, and then softened by allowing them to enter into a certain state of putrefaction, or by the action of acids. They are then immersed in an infusion of oak bark, which contains tannin, and in time converts them into leather. The process is continued sometimes for several months, the infusion being renewed from time to time, and is not arrested until the entire substance of the skin has become brown throughout. Sometimes infusions of other astringent vegetables containing tannin, such as valonia, sumach, catechu, and the barks of the willow, birch, elm, and Spanish chesnut, are substituted for oak bark.

This is ordinary tanning: but there are other kinds of leather, as follow:

*Tawed leather.* An insoluble compound of gelatine and chloride of aluminium. The skin is first steeped in an alkaline liquor, then in a solution of alum and common salt, which react on each other and produce chloride of aluminium and sulphate of soda. White glove leather is prepared in this way.

*Wash leather.* The skin is prepared and softened in the usual way, then steeped in oil, and afterwards in an alkaline solution.

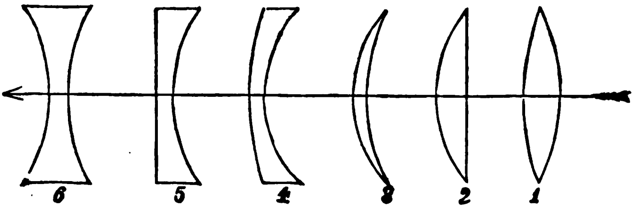
*Curried leather.* Common tanned leather while still moist is besmeared with oil, which as the water evaporates, takes its place in the pores of the leather and renders it waterproof. This is also called "upper-leather."

LEATHER VARNISH. If a sheet of paper, or a positive on paper, be first immersed in a solution of gelatine, dried, and then steeped in a solution of tannic acid, the gelatine will be rendered insoluble, and converted into a species of leather varnish; and by repeating the operation several times a considerable glaze may be communicated to the paper. This varnish, by filling the pores of the paper and rending it better able to resist the action of moisture and external agents, would no doubt tend to the preservation of the proof. Gallic acid has no such action upon gelatine, and must not be substituted for tannic by mistake.

LEMON JUICE. This is added to the nitrate bath in the process of printing by development upon plain paper; *q. v.* It contains about 6 per cent. of citric acid, some mucilage, and possibly a little oil of lemons; also a white, tasteless substance termed "hesperidin," which is soluble in 60 parts of hot water, and also in alcohol, and ether.

LENS. A lens is a transparent body constructed for the purpose either of concentrating or scattering rays of light transmitted through it.

Lenses are in general made of glass or rock crystal, and ground with spherical surfaces; the axis of the lens being the line joining the centres of the spheres, and therefore a line with respect to which the lens is symmetrical.

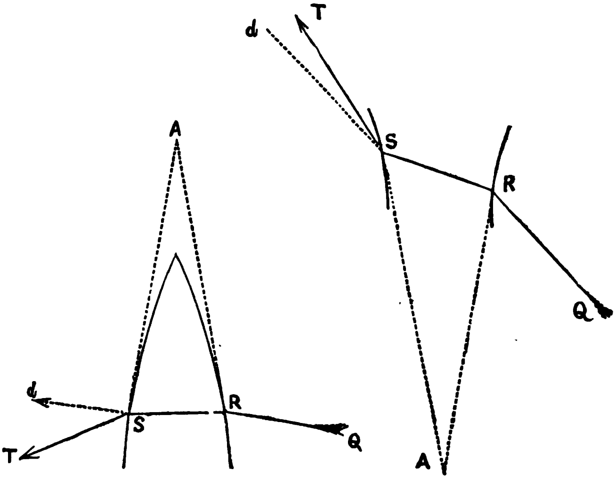


In the above figure six different forms of lenses are exhibited; and light is supposed to pass through them in the direction shewn by the arrow.

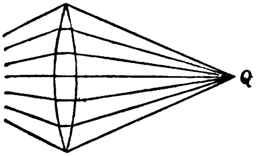
No. 1 is called "bi-convex; No. 2, plano-convex; Nos. 3 and 4, concavo-convex, or more frequently "meniscus;" No. 5, concavo-plane; No. 6, double concave. The nature of the surface upon which light is incident determines the first word of the compound appellative.

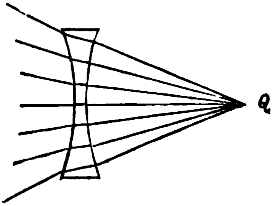
The first three lenses are thicker in the middle than at the edge, and are called "converging lenses," because they cause pencils that are refracted through them to *converge* more than they did before. Nos. 4, 5, 6, are thicker at the edge than in the middle, and are called "diverging lenses," because they cause pencils that are refracted through them to *diverge* more than before.

It has been shewn in the article on the prism that when a ray of light is refracted through a prism it is turned, or caused to deviate, *from* the edge of the prism. Now, we may suppose that the small portion of the spherical surface of a lens, on which a ray of light is incident, coincides with the tangent plane to the sphere at that point; and similarly with respect to that small portion of the opposite spherical surface from which the ray emerges.



If then QRST be a ray of light refracted through a lens, the small parts of the lens at R and S may be supposed to coincide with the tangent planes at those points, and these planes will in general intersect, if produced, in a straight line, thereby forming a prism whose refracting angle is SAR. Now, if we draw Sd parallel to QR, the emergent ray ST will have its angle of deviation, dST, *from* the edge of the prism, and will follow the course indicated in the figures. The mode in which a convex lens causes a pencil to converge, and a concave lens to diverge, will therefore be easily understood from the following figures, bearing in mind that the greater the angle of a prism may be, the greater is the deviation of a ray refracted through it.





No single lens is free either from spherical or chromatic aberration (*q. v.*). These errors are corrected by combining two or more lenses together. In a single convex lens, the surfaces of which have radii of different lengths, there is the least spherical aberration when the most convex side is presented to the incident pencil. When the refractive index of the glass is 1·5, the radii of the surfaces should be as 1 : 6, and the most convex side presented to the origin of light. This lens has the least spherical aberration of all single lenses, and is called the "crossed lens." If we call the aberration of the crossed lens unity, the following table, calculated by Sir John Herschel, shows the aberration of some other forms of lens :—

| | | |
|---|---|---|
| Crossed lens | | 1· |
| Double convex<br>„ concave | equal radii | 1·567 |
| Plano-convex<br>„ concave | | 1·081 |
| Convex side turned to parallel rays. | | |
| Plano-convex<br>„ concave | | 4·2 |
| Plane side turned to parallel rays. | | |

If two plano-convex lenses are placed with their convex sides in contact, and the focal length of the first be to that of the second as 1 : 2·3, the aberration will be only one fourth that of the single crossed lens.

Aberration may be entirely destroyed by placing a meniscus and convex lens with their centres in contact, according to the following table,—the convex lens being turned to parallel rays.

| | |
|---|---|
| Focal length of convex lens . . . | −10·000 |
| Radius of first surface . . . . | − 5·833 |
| ,, second surface . . . | +35·000 |
| Focal length of meniscus . . . | − 5·497 |
| Radius of first surface. . . . | − 2·054 |
| ,, second surface . . . | − 8·128 |
| Focal length of compound lens . . | − 3·474 |

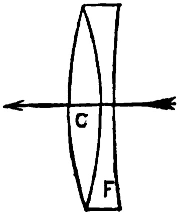
In correcting for spherical aberration the *same* kind of glass may be used for both lenses, but when chromatic aberration is cured by combining lenses in contact, they must be made of *different* kinds of glass. The principle on which lenses are achromatized is explained in the article "Prism." It is only necessary to remark in this place that the formula by which the central pencil refracted through a compound lens is rendered achromatic, does not also include the case of oblique and excentrical pencils, otherwise than as an approximation to the desired result.

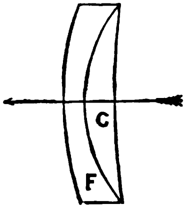
Having thus briefly introduced the subject of lenses, we will proceed to discuss more minutely the construction of those with which the photographer is principally concerned. They are the achromatized meniscus of Dr. Wollaston, intended principally for views, and the portrait and view combinations of Professor Petzval, the latter of which has been called by M. Voigtlander the "Orthoscopic lens."

### 1. The Achromatized Meniscus, or Common View Lens.

This lens is composed of two, which are cemented together with Canada balsam. The first is of flint glass, and double concave; the second of crown glass and double convex. The concavity of the front surface of the flint lens is very slight; this surface may even be quite plane. The radius of the inner surface is the same for both lenses, as they are cemented together. When this lens is used a stop is placed at a suitable distance in front of it.

But a lens of the meniscus form may be achromatized in two different ways. When the *flint* glass receives the incident rays the construction is that described above; but the *crown* glass may be placed so as to receive the incident rays. In this case the crown lens is a meniscus, and the flint lens concavo-convex. The two forms are exhibited in the following figs.:—the letters C, F denoting crown and flint.



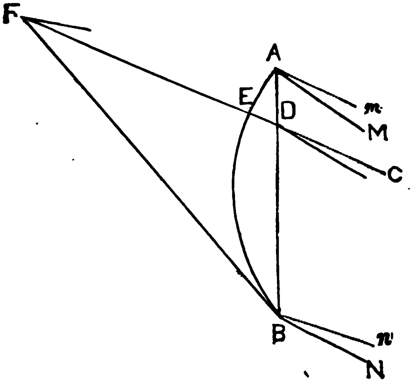


When the focal length of the achromatized lens, the radius of the front surface, and the materials used are the same, the focal length of the crown lenses are the same in both cases, and also the focal lengths of the flint lenses; the radius of the posterior surface is also the same in both cases. The first form has been in use for a number of years, but the second has been lately introduced and is said to give less spherical aberration.

The object of this view lens is to give a good image on a flat surface, pretty equally illuminated, and well defined, when an angular field of view of from 35° to 40° is included; the intensity of light in the image being a matter of secondary importance, and the spherical aberration being sufficiently reduced by the use of a small diaphragm. In other words, the object of this lens is to give a uniformly good picture, including a wide angular field, without particular reference being made to the amount of light admitted, or the time of exposure of the photograph.

The principle of this form of lens will be best understood by discussing, in the first place, the case of a single plano-convex lens, with a stop in front.

Let AB be a plano-convex lens presented to objects at such a distance that pencils from them may be considered cylindrical; and suppose an oblique cylinder of rays MANB from one of these distant objects not situated upon the axis of the lens, to be incident upon the plane side of it. Every ray of this large cylindrical pencil then suffers the same amount of refraction on entering the lens, and the pencil within the glass is a cylinder having its rays parallel to *m*A or *n*B. We have now done with the plane surface, and the case is simply that of a cylindrical pencil within a sphere about to emerge. It remains to be seen what becomes of it.



One of its rays DE, if produced backwards, passes through the centre C of the spherical surface. This ray does not suffer deviation at emergence, but proceeds in the same straight line, DE, produced to F. Rays emerging at an equal distance from E cut the line DF in the same point and have equal aberration, and the caustic surface is symmetrical with respect to EF, which is therefore its axis; and EF is equal to the principal focal length of the lens for a direct pencil.

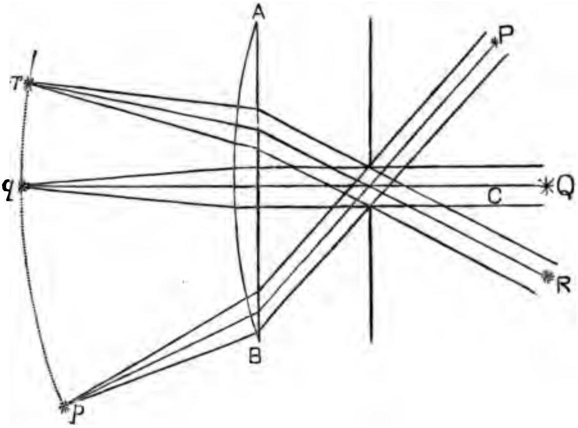
It appears therefore that EF is a constant quantity, not dependent on the obliquity of the pencil; CE is also a constant quantity, being the radius of the spherical surface AB; therefore CF is a constant quantity.

Hence it follows that when a plano-convex lens is directed to extremely distant objects, the image lies upon a spherical surface which has the same centre as the posterior surface of the lens.

This will perhaps be understood better by reference to the following figure:—

AB is the lens; C, the centre of the sphere AB; P, Q, R, fixed stars emitting cylindrical pencils of light; QC*q*, the axis of the lens; and *p*, *q*, *r*, the images of the stars, which lie on the spherical surface shown by the dotted line, and the centre of which is C.

The stop is placed, as shown in the figure, for the purpose of cutting off the outside rays of the pencils, and thereby reducing the amount of spherical aberration in each pencil. It will easily be seen that the position of the stop for any particular pencil depends upon its obliquity; and that the *greater* the obliquity the *nearer* the stop must be placed to the lens. In practice, the stop should be placed so as best to suit the *most oblique* pencils; but the inaccuracy thus introduced with respect to the less oblique pencils is hardly appreciable.



It will be seen by the foregoing figure that the amount of light in the image depends not only on the size of the stop, but also on the obliquity of the pencil, being greatest in the case of the direct pencil, and diminishing as the obliquity increases. For this reason there is not in the common view lens absolute equality of illumination, the centre of the field having the most light and the edges the least.

From the case of the single plano-convex lens, the transition is easy to that of the same lens achromatized, and thence to the achromatic meniscus. In these two latter cases it may be considered as very approximately true that the field for distant objects is a sphere concentric with the posterior convex surface of the lens.

If the stop be placed immediately in contact with the lens the radius of the field is shortened and the centre of the posterior surface itself, and not of the sphere of which it is a portion, becomes the centre of the field. This is explained in the article on the "Optical centre;" *q. v.* There would, however, be no *distortion* in this case, while there is considerable distortion when the stop is put at a distance from the lens, in order to get a flatter field. *See* "Distortion."

The general form and principle of the common view lens having now been described, it remains to give the exact formula for its construction.

The data are :—1st, the focal length of the lens ; 2nd, the indices of refraction for the crown and flint glasses ; 3rd, the dispersive powers of the glasses ; and 4th, the radius of the front surface. Let these quantities be expressed by the following symbols :—

$F$ = focal length of compound lens.
$\mu_1$ = refractive index of flint glass.
$\mu_2$ = „ „ crown glass.
$D$ = ratio of dispersive power of front glass to back glass.
$R$ = radius of anterior surface of lens.

The unknown quantities are :—

$s$ = radius of inner surface of lens.
$t$ = „ posterior surface of back lens.
$f_1$ = focal length of front lens.
$f_2$ = „ back lens.

Then, the equations which connect these quantities are—

$$\frac{1}{f_1}+\frac{1}{f_2}=-\frac{1}{F} \quad . \; . \; (1) \qquad \frac{f_1}{f_2}=-D \quad . \; . \; . \; (2)$$

$$\frac{1}{f_1}=(\mu_1-1)\left(\frac{1}{R}-\frac{1}{s}\right) \; . \, (3) \qquad \frac{1}{f_2}=(\mu_2-1)\left(\frac{1}{s}-\frac{1}{t}\right) \; . \; . \, (4)$$

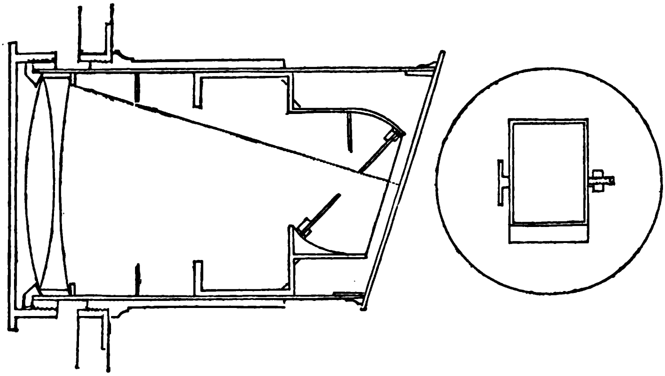
By which four equations, the four unknown quantities may be determined.

It is immaterial in the above formula whether the flint or crown lens be placed in front, so as to receive the incident rays. If the flint lens be placed in front, the formula gives the common view lens which has been in use for a number of years. If the crown lens be placed in front, the formula gives the lens shown by the second of the figures at page 255.

We have said that the radius of the front lens is arbitrary, but it depends upon the size of the lens and the work it is intended to do. As the lens increases in size the focal length remaining the same, the stop is placed further in front of it, the field becomes flatter, and there is more distortion ; at the same time the front surface must become flatter. When these conditions are reversed, *i. e.* as the lens becomes smaller, the stop is placed nearer to it, the field becomes more concave, there is less distortion, and the front surface should then become more concave. Some little latitude is therefore allowable in the radius of the front surface, and it may be considered as arbitrary, within certain limits; the mean being about 3 feet radius for a three-inch lens.

The second equation must be fulfilled in order that the lens may be achromatic. No attempt is made to cure spherical aberration except by the stop. The central pencil from Q would have a finer focus, *q*, if the small central portion of the lens through which it passes could be turned with its convex side to the incident rays. See what has been said before respecting the aberration of a plano-convex lens. The remark is equally applicable to the compound lens which is nearly plano-convex. The large lens of an opera glass, which is compound and convexo-plane, is placed with the *convex* side to the objects; and for the same reason the front lens of the portrait combination, which is nothing but a view lens reversed, has its *convex* side to the objects.

It now only remains to discuss the best mode of mounting the view lens; which is shewn in the following figure:—



The lens is placed in the tube with its concave side to the stop. A ring is then laid against the convex side, and it is screwed tightly in its place. The tube works in a jacket, which is screwed into a flange in the front of the camera; the open end of it is closed by a cap; and for better security to the lens a cap is also screwed on at the other end, when the instrument is packed for travelling. Within the tube, a little in front of the lens, is a fixed diaphragm; and in front of that a moveable tube which carries the front diaphragm, which can be so adjusted as to revolve within a projecting box, in order that its full aperture may be presented perpendicularly to the darkest part of the picture, and its edge, so to speak, towards the sky, or lightest objects; and at the same time any one of a set of stops of different sizes may be introduced as circumstances require. This contrivance is sufficiently explained by the figure. As the tube can be turned in the jacket, the plane of the stop, when placed obliquely to the axis of the lens, can be brought into any required position. The front part of the revolving disc which carries the stop, has a groove at the bottom and on both sides, and the stop, which is an oblong disc with a round hole in the middle, is slid into this groove like the lid of a box.

It will be seen that an annulus of the circumference of the lens is sacrificed, the lens must therefore be made so much larger as to allow for this. The object of this sacrifice of glass is to prevent the reflection of light from the broad edge of the lens. In the common mode of mounting the view lens this edge forms a broad luminous ring, which is seen on looking into the camera at the open end, and of course the light which enters the eye from this ring would fall upon a sensitive plate if put in the same position.

The diaphragms within the lens-tube entirely prevent the reflection of light from the inside of the tube. A strip of black cotton velvet should be wound round the edge of the lens before putting it into its cell; and both the inside of the tube and diaphragms should be blackened with a mixture of lamp black and spirit varnish. There are times when it is convenient to be able to push the diaphragm nearer to the lens, and no mounting is complete which does not admit of this being done when necessary.

When a very small stop is used the diameter of the circular space covered by the lens with good detail is nearly equal to its focal length.

Distant objects have a shorter focus than near ones. If $f$ be the principal focal length of the lens, $u$ the distance of an object from it, and $v$ the focal length of the lens for the distance $u$, then $v$ is determined by the following equation :—

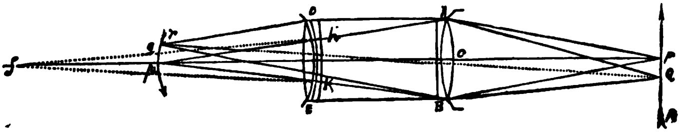
$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u}$$

Since the field for objects equidistant from the lens is concave and not flat, it follows that the objects at the sides of the picture should, if possible, be nearer to the lens than those in the middle. When this cannot be managed recourse must be had to a small stop, which, by cutting off the outer rays of pencils, renders them very long and attenuated in the neighbourhood of their focus, and then the picture may be placed a good deal out of true focus in places without appreciable loss of detail. By means of the small stop, objects at unsuitable and greatly varying distances from the lens, can therefore be brought into tolerably good focus upon a flat focussing screen.

### 2. M. PETZVAL'S PORTRAIT COMBINATION.

The object of this instrument is to obtain an image well defined in its principal parts, *when a large volume of light is admitted.* In taking a portrait it is evident that the time of exposure should be reduced as much as possible, because after remaining in a constrained position for a long time the features of the sitter betray an expression of the discomfort felt. A lens of large aperture must therefore be employed in portraiture, so long as photographic processes remain in their present state of insensitiveness. As soon however as the chemist shall discover the means of rendering these processes more sensitive, the optician will be released in a corresponding degree from the necessity of constructing lenses of large aperture, and the defects to which such lenses are liable, and which admit of no remedy, will be avoided by using smaller apertures. The nature of the defects of large lenses have, however, been misunderstood and exaggerated by persons ignorant of mathematics.

The portrait combination of Professor Petzval is that which has been generally adopted by opticians, and the arrangement of the lenses is exhibited in the following figure.



The front lens A B is a compound lens, exactly like the common view-lens, but placed with its *convex* side to the objects. It is achromatic, but not entirely aplanatic; this defect being remedied by the posterior lens.

The posterior lens is composed of two lenses separated by a small space; that next the front lens is of flint glass, convexo-concave, and *divergent*, being thinner in the middle than at the edges; the other is biconvex, and of crown glass, being placed with its most convex side next to the concavity of the flint, as shewn in the figure.

The posterior compound lens is achromatic, and the object of separating the lenses and giving them curves so different from that of the front lens is to cure *spherical aberration* in the entire combination.

Both lenses are therefore convergent, and the effect of the posterior lens is to shorten the focus of the front lens. It may be well to observe in this place that when a *con*vergent lens is rendered achromatic by combining two lenses of different kinds of glass, the concave lens must be of flint, and the convex lens of crown glass. On the other hand, when a *di*vergent lens is achromatized, the concave lens must be of crown, and the convex lens of flint glass.

The dimensions of this form of lens, given by measurement of one which we constantly use and which is now before us, are as follow:

| | | |
|---|---|---|
| Aperture of front lens . . . . | 4 | inches |
| Focal length of ditto . . . . . | 36 | ,, |
| Aperture of back lens . . . . | 4 | ,, |
| Focal length of ditto . . . . . | 24 | ,, |
| Distance between lenses . . . . | 6 | ,, |
| Focal length of combination measured from back lens . . . . . | 13⅓ | ,, |
| Focal length of combination, reversed | 12 | ,, |

The curves depend entirely on the refractive and dispersive powers of the glass used, and as these vary with every "pot of metal," it might only mislead the reader were we to state the exact curves of the lenses of the instrument before us.

To return to the figure.

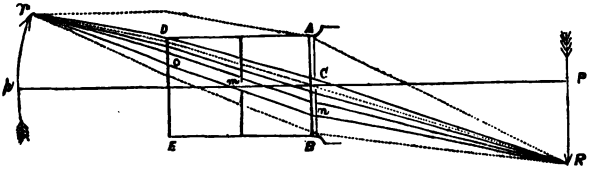
Let PQR be an object placed before the lens, P being a bright point upon its axis. A direct pencil from P covers the entire surface, AB, of the front lens, and is refracted by it towards a point *f*. This converging pencil A*f*B is incident upon the portion *hk* of the posterior lens, and is by it refracted to a point *p*, at which the image of P is formed. It will be observed that *hpk* is a cone of light having a very large vertical angle *hpk*; both spherical and chromatic aberration must therefore be accurately corrected in such a pencil, and the focussing screen placed accurately at *p*, or the indistinctness of the image would be considerable. The optician has therefore greater difficulties to encounter in the construction of the portrait lens than in that for views.

We have next to consider the case of an oblique pencil.

The central pencil does not cover the whole of the back lens, (which is the same size as the front lens,) but merely the central portion, *h k*. The angle DA*h* is about equal to 3°. If therefore an oblique pencil, as QAB, makes an angle QCP of about 3° with the axis of the lens, the upper ray of the refracted pencil will run along the tube A D, and the whole pencil will come to a focus at *q*. The image therefore between *p* and *q* will be equally illuminated. But if a more oblique pencil, as that from R, be incident on the lens, only a portion of the refracted pencil can pass through the back lens, the remainder of it being cut off by the upper part of the tube, which reflects it in the manner shown in Fig. 3, page 59. This is one of the great defects of the portrait lens, and the mode of mounting it. Sometimes the back lens is made a little larger than the front lens, and then the equality of illumination extends over a greater space, but the outer portion of a *large* back lens does not perfectly cure spherical and chromatic aberration, and from this cause indistinctness is introduced. The fact is, the portrait lens with full aperture has many serious defects, and the sooner photographers are enabled to give up using it the better. It should never be used from choice, but only from necessity.

The field of a portrait lens is not nearly so flat as that of a view lens of equivalent focus; and the angle of view properly included by a portrait lens is much narrower.

When the light is sufficiently good, a stop may be used with a portrait lens; and the question has arisen as to which is the proper place for it—in *front* of the front lens, or *between* the lenses. This question we will discuss with the help of the following figure:—



The lenses are represented by the lines AB, DE, as before. R is the origin of an oblique pencil, the axis of which, RC, makes the same angle with the axis of the lens, as if it were the extreme oblique pencil of a view lens, *i. e.*, PR is about equal to one-third of PC. Now CA is equal to one-third of AD, and the line RC suffers little or no refraction on passing through the front lens, therefore the axis of the refracted pencil between the lenses passes very nearly through D, as shown in the figure.

Now we may suppose that a whole pencil, RAB, comes accurately to a focus at *r*, for if it does not, the lens is worthless, inasmuch as it *ought* to cure spherical aberration in the oblique, as well as central pencils, when the focus is merely examined by unassisted vision. We may assume therefore that every ray of the pencil RAB which really passes through the back lens, passes also through *r*. This being understood, it follows that by placing a stop midway between the lenses, at *m*, a small excentrical portion, R*n*, of the large pencil R A B is incident at *n*, passes through the stop at *m*, the back lens at *o*, and then comes to a focus at *r;* while if a small stop is placed at *c*, the *central* portion of the large pencil RAB passes through it; then through the back lens at D, and thence, as before, to *r*.

When, therefore, a *very small* stop is used, it scarcely matters whether it be placed at *c* or *m;* but if a *larger* stop be used, it would obviously be better placed at *m*, because if placed at *c*, a portion of the rays of the refracted pencil would be cut off by the tube, and there would not be equality of illumination in the image. It must be remembered, however, that the focus at *r* is not *absolutely* perfect, and that, *theoretically*, the rays incident at C go to *r* with less spherical aberration than those incident at *n*.

But a portrait lens is not intended to be used with a small stop. When a small quantity of light will do the work required, it is far better to use the orthoscopic lens. Nevertheless, stereoscopic pictures are sometimes required to be taken instantaneously, and sometimes with the ordinary exposure for views; in this case a pair of small portrait lenses, furnished with stops, will answer both purposes, inasmuch as stereoscopic pictures need not include so wide a field as ordinary views.

The best arrangement for taking instantaneous pictures, including a tolerably wide field, with a lens of large aperture, is as follows:—

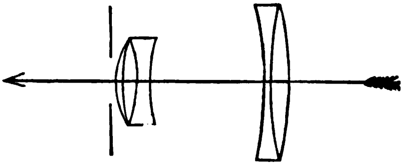
Reverse the portrait lens, that is, turn it with the posterior lens to the objects; and let the other lens, which is a view lens, be made larger than usual. Then place a stop immediately in contact with the lens that is presented to the objects. The arrangement will then be as represented in the figures at pages 60, 61, and 67; and this will give a much flatter field than the portrait lens used in the ordinary way, and the picture will be more *uniformly* covered with good definition, and more equally illuminated, although possibly it may not be quite so good as before in the centre. The focal length of the combination is a trifle shorter when used in this way.

A portrait lens, therefore, is only intended to be used for subjects which must be taken quickly, or instantaneously. It does not give so flat a field as a view-lens; nor does it give equality of illumination; nor can objects at different distances be all brought into good focus; nor does it include a wide angular field; nor does it give images free from distortion. In short, everything is sacrificed to the centre of the picture, and the lens should only be used when no other will answer the purpose. As for using a stopped portrait-lens, instead of a view-lens, for ordinary out-of-door pictures, the principle is incorrect for the reasons which have been stated, and the plan only answers when a narrow field of view is included.

The next lens to be described is the best of the three, and every photographer should possess one. It has been called the "Orthoscopic lens," or "Compound View-lens," and the following is a description of it, given by us in the "Photographic Notes," No. 49, April 15, 1858, shortly after its introduction into this country.

3. The Orthoscopic Lens.—The term "orthoscopic" is derived from the Greek words ορθος right, and σκοπεω I see. The meaning is that the lens gives images more free from distortion than other lenses.

The orthoscopic lens is an arrangement consisting of two achromatic compound lenses separated by an interval, as shown in the figure.



The front lens is the larger, and is the same as the front lens of the present combination for portraits; that is to say it is composed of a double convex lens of crown glass, cemented with Canada balsam to a concave lens of flint, the entire lens having *negative* focal length—that is, causing parallel rays to converge to a focus on the *opposite* side of the lens to the origin of light.

The posterior lens is an achromatic compound lens formed of two, not cemented together but merely touching at the edges, and having a space between them in the middle, as shewn in the figure. The inner lens is of crown glass, and double concave, the flatter side being next to the front lens. The outer lens is a meniscus of flint glass, having its convex side outwards and next to the picture. The deepest concavity of the crown lens is therefore opposite to the concavity of the meniscus. As these lenses are not cemented together but have a cavity between them, their inner surfaces may sometimes require wiping; they are therefore merely deposited in the cell which receives them, and are fixed in their place by a countercell which is screwed until it touches a brass ring laid in contact with the outer lens. When a stop is used it is placed between the ring and the countercell, as shewn in the figure. The diameter of the posterior lens is about two-thirds that of the front lens, and the distance between them is about half the diameter of the front lens.

The posterior compound lens has *positive* focal length, and would cause parallel rays to *diverge* from a point on the *same* side of the lens as the origin of light. The front lens therefore tends to bring parallel rays to a focus, the back lens to scatter them wider apart. In popular language the front lens is convex and magnifies, the back lens is concave and diminishes.

We would take this opportunity of observing that in optics the signs *plus* and *minus* are introduced into formulæ from their property of being able to represent not merely the operations of addition and subtraction, but also contrariety of position or direction. By calling lines measured on one side of a lens positive, and on the other side negative, and affixing the signs *plus* or *minus* to the magnitude of a line, according to its position, it is possible to make one formula include a great variety of different cases. The convention adopted in optics is, to call lines measured from the lens *towards* the origin of light *positive*, and in the opposite direction negative. In other branches of mathematics it is found very convenient to adopt similar conventions in which the signs *plus* and *minus* indicate *opposite qualities*, as well as mere addition and subtraction.

The exact particulars of the compound lenses are as follow :—

| | | | |
|---|---|---|---|
| Front lens—Diameter. . . . . . . | 8 | centimètres | |
| Focal length. . . . . . | 40 | do. | (Negative) |
| Back lens—Diameter. . . . . . . | 5 | centimètres. | |
| Focal length. . . . . . | 90 | do. | (Positive) |
| Distance between the lenses | 4 | centimètres. | |
| Focal length of entire combination . . . | 63 | do. | (Negative) |
| Diameter of the field . . . . . . . | 54 | do. | |

[A centimètre is about two-fifths of an inch.]

These dimensions apply to the 3-inch lens, but by dividing or multiplying them all by any given quantity, the corresponding dimensions of any other size of lens may be obtained.

The front lens is placed with its convex side to the view, and the back lens with its convex side to the picture.

Since the front lens of this new instrument is the same in every respect as the front lens of the portrait combination, the latter may be converted into the former by removing its posterior lens and substituting for it the posterior lens of the orthoscopic combination, mounted, of course, at its proper distance from the front lens.

In order to cut off reflected light from the inside of the tube, a stop is placed midway between the front and back lens; but not so as to intercept any of the legitimate rays of light

Such is the construction of the orthoscopic lens. It is essentially a View-Lens, and is not intended for portraiture. We have therefore to discuss its merits as a view-lens when compared with the ordinary form, and in doing so must direct our attention more particularly to the following points :—

1st,—Flatness of field, and the included angle of view.

2nd,—Freedom from distortion.

3rd,—Equality of illumination.

4th,—Perfection of focus, and freedom from spherical aberration.

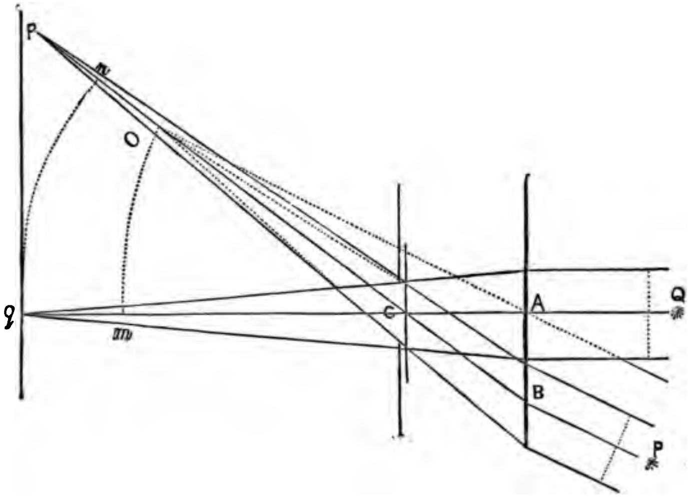
5th,—Coincidence of the visual and actinic foci.

6th,—General convenience, freedom from diffused light, copying powers when the focus is elongated, power of rendering aerial perspective, and other good qualities.

We shall discuss these matters in the order in which they stand.

1st,—Flatness of field, and the included angle of view.

In determining the flatness of field of any lens, we have to compare the course of the most oblique with that of a direct pencil; and the simplest plan is to suppose the pencils cylindrical, or that the lens is pointed at extremely distant objects; should it be found to answer well in this case it will be equally good for all ordinary purposes.



In the above figure the lenses are represented by straight lines strong and black, the front lens passing through A and the back lens through C; A C$q$ being their common axis. A stop is placed behind the back lens, and in contact with it. In order to fix the ideas, and render what we have to say more intelligible, we shall suppose the lens to be a No. 1, having a combined focus of rather more than 11 inches, and covering a picture 10 × 8, with a half-inch stop.

It will be seen, from the above figure, that the oblique pencil passes *ex*centrically through the front lens and *cen*trically through the back lens. If, then, $q$ be the focus of the direct pencil from a distant point Q, and $p$ the focus of an oblique pencil from a distant point P, we have to compare the length C$p$ with C$q$, in order to discover the flatness of field, and how far it deviates from a sphere whose centre is C; and we would observe that unless it *does* deviate, and that pretty considerably, from such a sphere, the lens would be next to worthless for the purpose intended. We have to show, then, that the focal length, C$p$, of the oblique pencil, is greater than the focal length, C$q$, of the direct pencil, and to calculate the difference between them.

Let us consider first the case of the direct pencil incident at A. After refraction through the front lens it converges towards $m$, the the principal focus of that lens; the distance A$m$ being 8 inches (in round numbers). This converging pencil is then refracted by the posterior lens, the positive focal length of which is 18 inches (in round numbers). The effect of this is to diminish the convergency of the rays and bring them to a focus at $q$, which is further than $m$ from C. The distance A C being one inch, C$m$ is 7 inches, and C$q$ is then found in the following way:—

Multiply 7 by 18, and divide the product by their difference;—that is, divide 126 by 11. This gives C$q$=11 $\frac{5}{11}$ inches.

Next, let us consider the oblique pencil which proceeds from a distant point P, is incident *ex*centrically on the front lens at B, and passes centrically through the back lens at C.

Through A, the centre of the front lens, draw a dotted line A O, parallel to B P, and with A as centre, and A$m$ as radius, strike an arc of a circle cutting A O at O. Then, A O equals 8 inches; and the oblique pencil at P will, after passing through the front lens, converge towards the point O (as shown by the dotted lines).

Now we come to the pith of the matter. What happens at the second lens?

We have at the second lens an oblique pencil, incident centrically, and converging towards O. Join therefore C O, and produce it to $p$.

Also, with C as centre and C*q* as radius, strike a circle cutting C*p* at *n*. C*n* is therefore equal to C*q*.

Now, adopting the same formula as in the former case in order to find C*p*, we must multiply CO by 18 and divide the product by their difference. What then is the length of CO?

In the reply to this query will be seen the great ingenuity of M. Petzval's arrangement; for it appears that CO is greater than C*m*.

The proof of this is easy enough. Any two sides of a triangle are, together, greater than the third, therefore OC and CA are together greater than AO, and therefore than A*m*. Take away the common part AC, and CO is proved to be greater than C*m*.

The actual difference between CO and C*m* in the No. 1 lens, with the extreme oblique pencil, is about the one tenth of an inch. If then we multiply $7\frac{1}{10}$ by 18 and divide the product by their difference, we get $Cp=11\frac{79}{109}$ ins. The difference between C*o* and C*m*, (*np*,) is therefore nearly one-third of an inch. This is of course in favour of flatness of field, because it brings *p* nearer to the plane through *q*.

In the common view lens, presented to extremely distant objects, the field is very approximately a sphere the centre of which is the centre of the convex surface of the lens. On taking the exact dimensions of the orthoscopic lens, and working the problem out completely, we find that, as regards flatness of field, the common view lens has a little the advantage; and this result of theory is also borne out by the experiments we have made with both forms of lens differing but little in their focal length. In what follows, however, we shall show that in other respects the orthoscopic lens has many and great advantages over the common view lens.

So much for flatness of field. Next, with respect to the angular extent of the field of view. It might be supposed that the common view lens having the advantage in *flatness* of field, it ought to include a wider angular field; but that is not the case, because the distortion produced by the common view lens is so great, and becomes so unbearable when a certain small angle of field is exceeded, that it is necessary from this cause to restrict that angle to about 35°. In the case of the orthoscopic lens, the distortion is not only different in *character*, but much less in *amount*, and therefore, although the field is not absolutely so flat, still an angle as great as 47° may be included. This is a great merit of the orthoscopic lens, and one which should recommend it particularly to the notice of the landscape photographer; because the bad effects of curvature of the image may be remedied by using a small stop, but for distortion there is no such remedy. A small stop gives a finer point to the pencils, but does not affect the curvature of the lines of the picture.

We now come to the 2nd topic, viz: Freedom from distortion.

In the common view lens with the stop in front, the oblique pencils do not pass straight through the margin of the lens, but are bent out of their course, inwards, towards the centre of the picture. This produces distortion, in a way in which we will endeavour to explain. Suppose the stop extremely small, and the lens removed; a perspective view would then be formed on the focussing screen, but larger than the picture produced by the lens, and quite free from distortion. Suppose a plain irregular polygon to be the figure represented, the angles of which on the focussing screen are points A, B, C, D, &c., and let O be the point where the axis of the camera cuts it. Draw radial lines O A, O B, O C, O D, &c. Now introduce the lens. In consequence of the deflection of the axes of the pencils which pass through the margin of it, towards the point O, the image of the polygon will be smaller than before, and its angular points *a*, *b*, *c*, *d*, &c., will lie on the lines O A, O K, O C, &c., nearer to O. Now if the decrements *a*A, *b*B, *c*C, &c., were exactly proportional to the radial lines OA, OB, OC, &c., the small polygon *abcd* would be exactly similar to the large one ABCD—and there would be no distortion; but no such law is observed in the production of these decrements as that of direct proportionality to the radial line, and the greater the radial line may be, *a fortiori* greater the decrement becomes. This produces distortion, and causes all straight lines which do not pass through the centre of the picture, to be bent inwards at their extremities. *See* "Distortion."

Now let us turn to the orthoscopic lens. Here we see that the axes of the oblique pencils are bent *outwards* out of their course, and a *larger* picture produced than if a small hole, without lenses, were put at C. Instead of *de*crements we have now *in*crements of the radial lines—and the production of these increments depends upon a different law from that of the decrements in the former case, and produces less distortion. What little distortion there is, has the effect of rendering straight lines *convex* to the centre of the picture, by bending their extremities outwards, but this defect is so inconsiderable as to be scarcely appreciable, and so far as it exists it has the *good* effect of increasing the comparative size of the *side* objects, and therefore throwing the central objects apparently further back; while the common view lens has the opposite effect to such an extent as to interfere greatly with the aerial perspective, by diminishing the objects at the sides of the picture, which are generally the nearest, and thereby bringing the central and generally most distant objects apparently too much forward.

3rd,—Equality of illumination. Through *m* imagine a line *mk* drawn at right angles to $m$C, and cutting C$p$ in $k$. Now let a straight line passing always through this imaginary point $k$ sweep round the circumference of the stop at C and mark out with its end a circle on the front lens, in the neighbourhood of B, which would be its centre. Similarly, let a line passing through $m$ sweep round the circumference of the stop and trace another circle on the front lens, the centre of which would be A. These two circles viz., that at A and that at B will be equal to another. But if instead of the point $k$ we take the point O, nearer to C, the circle at B will then become *larger* than before and consequently larger than that at A. Hence it follows that the area on the front lens covered by an oblique pencil is *greater* than that covered by the direct pencil. On the other hand the obliquity of the pencil occasions loss of light, as shown by the dotted lines across it. The gain from one cause does not entirely compensate for the loss from the other, and there is not *perfect* equality of illumination; but in the common view lens there is loss from obliquity of incidence without *any* set off to counterbalance it. The orthoscopic lens has therefore the advantage as regards equality of illumination.

4th,—Perfection of focus, and freedom from spherical aberration. In the common view lens *no* attempt is made to cure spherical aberration, or improve the focus, except by means of the stop. Everything is sacrificed to flatness of field. There would be *much* less spherical aberration in the central pencil if the lens could be turned with its convex side to the view. But in the orthoscopic combination spherical aberration may be, and is, *completely* remedied, and the quality of the focus, both of the direct and oblique pencils, greatly improved.

5th,—Coincidence of the visual and actinic foci. With four glasses instead of two, more lines of the spectrum may be united, and therefore the chemical focus improved, so that the orthoscopic lens has the advantage in that respect.

6th,—In lightness and convenience, and freedom from diffused light, the orthoscopic lens has greatly the advantage over the other. In copying, the common view lens cannot be used when the copy is to exceed one half the size of the original; but when the focus of the orthoscopic lens is lengthened by bringing the object near it, it gives a sharp and good image up to full size. It is in fact the best copying lens that has yet been produced.

We have now discussed minutely the three forms of lens mostly used by photographers. It only remains to describe the mechanical means by which lenses are ground and polished.

### The Grinding and Polishing of Lenses.

The piece of glass of which a lens is to be made is cut out of a plate of sufficient thickness, and this is brought roughly into shape by means of pincers, a grind-stone, and an old mould. A pair of guages and moulds are required for each surface of the lens. The pair of guages are made by striking the required curve on a brass plate, and cutting through the line very accurately; one of the guages is therefore convex, the other concave.

Two moulds are then made of brass or iron, and turned in a lathe, to fit the guages. One of these moulds is therefore hollow, the other convex. To ensure accuracy they are then ground one against the other, with some fine emery between them.

The piece of glass to be ground is now attached to a holdfast by a few drops of melted pitch. The holdfast is a round brass plate a little smaller than the lens. The mould is then applied to the upper surface, together with some coarse emery and water, and the grinding is accomplished by hand, by turning the mould continuously round upon the glass, giving a cross rub now and then, using gentle pressure, and taking care that the edge of the mould never goes beyond the centre of the glass. When the glass has assumed the shape of the mould, and touches it in every part, the coarse emery is washed off and finer emery substituted for it. The grinding is then continued until the surface of the lens assumes a uniform dead appearance, and all scratches are removed. During this process the mould which is in use is frequently ground against the other, in order to prevent any change of form that might occur in it. Having proceeded thus far, finely powdered pumice stone is substituted for the fine emery, and after a little more grinding the surface is ready for polishing. The other surface of the lens is then treated in the same way.

It now remains to polish the surfaces.

This is done with moulds of pitch; and fine colcothar is used instead of emery or pumice powder. (Colcothar is the red peroxide of iron, called "Rouge," or jeweller's polishing powder; *q. v.*) The polishing moulds are made thus: equal parts of pitch and resin are melted together and poured into the metal mould (which is previously heated), to the depth of about a quarter of an inch; the cold mould is then laid upon the melted pitch, and when it has set the whole is thrown into water and suddenly cooled. The cold mould is then detached from the pitch.

As the polishing proceeds the pitch becomes hot with the friction, and sticks to the glass, so that the labour of polishing increases towards the end of the operation, which must not be interrupted until finished. A drop or two of water is added to the colcothar at first, but no fresh colcothar or water are afterwards added. If the pitch becomes too adhesive it must be breathed upon.

Lenses are sometimes ground by machinery, but hand grinding is thought the best for fine work.

An account of the kind of glass used for photographic lenses, and the defects to which it is subject, is given in the article "Optical Glass;" *q. v.*

LIGHT. What is light? Why does it render objects visible, exhibit different colours, produce chemical changes in bodies, and so forth? These are questions of the highest importance in science, and of especial interest to the photographer. We shall endeavour briefly to explain in the present article what light is, and why it produces many curious phenomena of which no photographer should be ignorant.

Two theories have been advanced with respect to the physical nature of light, one called the "Corpuscular," the other the "Undulatory" theory. On the former hypothesis it was supposed that a luminous body emits particles of light, just as a fowling piece discharges a volley of small shot, and that these minute particles, after travelling through space with immense velocity, at length impinge upon bodies. On the undulatory theory it is supposed that a luminous body communicates undulations to an elastic ether which pervades space, that these undulations are transmitted with prodigious velocity, and that they constitute light.

We speak of the corpuscular theory in the *past* tense because it has now been abandoned by men of science as incapable of explaining some of the most important phenomena of light; and we speak of the undulatory theory in the *present* tense, because it is now generally adopted, aud considered to rest on quite as satisfactory evidence as the Law of Universal Gravitation. In the preface to Professor Airy's "Tract on the Undulatory Theory of Light," he expresses himself thus strongly on the subject:—

"The undulatory theory of optics is presented to the reader as having the same claims to his attention as the Theory of Gravitation,—namely, that it is certainly true, and that by mathematical operations of general elegance it leads to results of great interest. With regard to the evidence for this theory; if the simplicity of a hypothesis which explains with accuracy a vast variety of phenomena of the most complicated kind, can be considered a proof of its correctness, I believe there is no physical theory so firmly established as the theory in question. This can be felt completely, perhaps, only by the person who has both observed the phenomena and made the calculations; as to my own pretensions to the former qualification, I shall merely state that I have repeated nearly every experiment alluded to in the following tract. This character of certainty, I conceive to belong only to what may be called the *geometrical* part of the theory; the hypothesis, namely, that light consists of undulations depending on transversal vibrations, and that these travel with certain velocities in different media, according to the laws here explained. The *mechanical* part of the theory, as the suppositions relative to the constitution of the ether, the computation of the intensity of reflected and refracted rays, &c., though generally probable, I conceive to be far from certain."

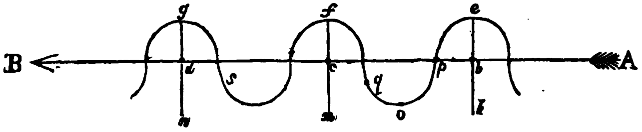
Such are the opinions of the Astronomer Royal, expressed in the year 1831, with respect to the certainty of the undulatory theory of light; but since that time some points of difficulty in the hypothesis have been cleared up, and it now rests on a firmer basis than ever. In fact the Corpuscular Theory is now completely exploded, and we allude to it as a matter of history, as we might to any exploded system of Astronomy. Should the reader, therefore, find in any popular treatise on Optics the Corpuscular Theory treated with any sort of gravity or respect, or in any way than as a delusion, he may infallibly conclude that the author is but imperfectly acquainted with his subject.

Light, then, is the undulation of an ether which pervades space, just as Sound is the undulation of the air; but both the media and the species of undulation are different in the two cases. Air is a material ponderable substance,—lumeniferous ether, an imponderable substance, and therefore not strictly material according to the definition of matter (*see* "Imponderable Agents"); still it *may* be, and no doubt *is* material, although it has not actually been *proved* to possess weight. Should space be filled with a material ether, however subtle, it would act as a resisting medium to the motions of the heavenly bodies, and in the case of the comets which have but little mass, and move with enormous velocity, its effect as a direct force continually opposing their motion would be to cause them to describe smaller orbits in an appreciably shorter period of time. Now it is found that the periods of the comets of Encke and Biela *are* actually diminished by a few hours in every revolution round the Sun; but this may happen in consequence of their passing through nebulous matter which appears to surround the Sun for a considerable distance, so that it does not afford absolute proof of the materiality of the lumeniferous ether, although it increases the probability of its being subject to the common laws of grosser matter.

The species of undulations are also different in the cases of Light and Sound. In common light the vibrations of the molecules of ether take place in a line *at right angles to the direction* of propagation of the ray; in sound the particles of air vibrate *in the direction* of propagation. The undulations of light may be compared to those produced by throwing a stone into a smooth and deep pond of water; those of sound to the waves produced in a field of corn when the wind sweeps over it. In the former case, that of the water set in motion by the stone, each particle of water moves up and down in a *vertical* line; in the case of the field of corn, each ear of corn moves backwards and forwards in a *horizontal* direction, or something approaching to it. The illustration is certainly far from being perfect, but it may assist the reader in forming a true conception of the difference between light and sound. There is also a great difference between the velocity of propagation, and length of the wave in the cases of light and sound. Light travels in vacuo at the enormous rate of 192,000 *miles* in a second, and the average length of a wave of light is about the one fifty-thousandth part of an *inch;* while sound only travels at the rate of about 1100 *feet* in a second, and the length of a wave of sound capable of affecting the auditory nerves of man, lies between a few *inches* and several *feet,*—the short wave most frequently repeated giving the high note, the long wave less frequently repeated, the low note.

But before carrying these analogies any further, we will endeavour to explain more clearly the precise nature of an undulation of light.

A luminous body is supposed to be a material substance the particles of which are in a state of intense agitation. These set in motion the molecules of ether next to them, and this motion is communicated from molecule to molecule, along a line of molecules, with amazing velocity, and in the following manner:



Suppose AB to be the direction of a ray of light, and *bcd* atoms of ether; then, the atom *b* oscillates or vibrates up and down along the line *el*, at right angles to AB; the atom *c* along the line *fm*: *d* along the line *gn*; and so on.

The velocity of the atom at *b* gradually decreases as it moves towards *e*, and on arriving at *e* altogether vanishes; the molecule then returns towards *b*, acquiring fresh velocity as it approaches *b*, attaining its maximum of velocity at *b*, then gradually losing it again as it approaches *l*, and losing it entirely at *l*; after which it returns to *e* as before; and so on. Similarly with respect to every atom along the line AB; and it must be clearly understood that no atom actually travels from A towards B, but merely continues to vibrate through an exceedingly small space in a line at right angles to AB.

This being understood, we have to explain how an *undulation* is produced and propagated. It will be remembered that although light travels with amazing velocity, yet that velocity is measurable and finite, so that a molecule of ether, *b*, at one part of the line AB may be vibrating, while another molecule, *d*, is at rest. Suppose then we consider the state of the vibrating atoms which constitute a ray of light, at a particular epoch of time. It is evident that one atom may be at *e*, while another is at *p*, another at *o*, another at *q*, another at *f*, and so on. If then we draw a curved line through the instantaneous positions of the atoms, *epoqf*, that curve will represent an undulation, or wave of light; and the particles *e* and *f*, *q* and *s*, are said to be in the same "phase" of undulation; the length of the wave being the distance *ef*, or *qs*.

A ray of common light is composed of undulations which are propagated in the manner described in all possible planes passing through AB. A ray of "plane polarized light" is one in which the undulations are propagated in only *one* plane which passes through AB. A ray of "circularly polarized light" is one in which the curved outline of the undulation, instead of lying on a plane, forms a spiral round AB like the thread of a corkscrew, and called a "helix." A ray of "elliptically polarized light" is one in which the spiral, instead of being coiled, so to speak, round a *circular* cylinder, as in the former case, is coiled round an *elliptical* cylinder. The subject of polarized light will be discussed presently.

The effect produced by a ray of light is due to the blow of the last vibrating atom against the material substance upon which it is incident. As the undulations are propagated by the luminous body continuously, these blows follow one another in rapid succession, and a vast number of very small blows thus administered produce an appreciable effect in a finite time. This effect is moreover considerably increased when a number of rays are brought to a focus, and act upon the same point.

LIGHT, therefore, is MOTION; or shall we say that light is the means by which a blow is transmitted from the luminous body to the body upon which light is incident.

Light travels in vacuo with uniform velocity; but there are different kinds of light, that is, light which exhibits different colours, viz. red, orange, yellow, green, blue, indigo, violet. These different colours are produced by *the different lengths* of the waves of light, as exhibited in the following table:

| | | |
|---|---|---|
| Extreme red | ·00075 | millimètres |
| line A in Spectrum | ·00074 | „ |
| B „ | ·0006879 | „ |
| C „ | ·0006559 | „ |
| D „ | ·0005888 | „ |
| E „ | ·0005265 | „ |
| F „ | ·0004856 | „ |
| G „ | ·0004296 | „ |
| H „ | ·0003963 | „ |
| I „ | ·00037 | „ |
| Extreme violet | ·00036 | „ |

Hence it appears that the waves of red light being the longest, the number of undulations in a given time are the fewest; and the waves of violet light being the shortest, its undulations are the quickest.

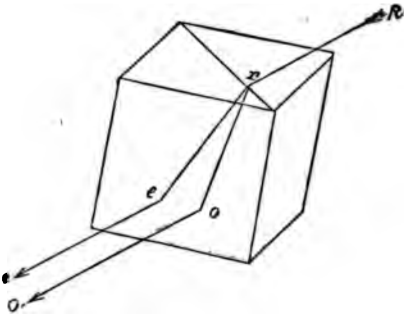
When light passes from vacuum into a transparent medium, or from a rare medium into a denser, the velocity of the waves is diminished, and *vice-versâ*. The index of refraction, "$\mu$," in geometrical optics, expresses in physical optics the ratio which the velocity of a wave of light in vacuo bears to its velocity in the medium into which it passes. This quantity "$\mu$" is greater for violet than red light; it would appear, therefore, that their velocities being equal at incidence, the red ray travels faster through a refracting medium than the violet ray. There would consequently appear to be a connection existing between the length of a wave and the velocity of its propagation. This circumstance is stated as a difficulty at page 285 of Professor Airy's Tract on the Undulatory Theory of Light. The difficulty has, however, been since removed by Professor Powell, of Oxford, who has demonstrated that within a refracting medium there *is* actually a difference between the velocities of red and violet light, the condition being that the intervals between the vibrating molecules of ether should bear a sensible ratio to the length of an undulation, which condition is fulfilled within the refracting medium, although apparently not in space, where the velocity of light of all colours is the same.

All material bodies are supposed to be more or less elastic, their particles not being in actual contact, and the interstices between them filled with lumeniferous ether. It is easy to conceive therefore that the chemical phenomena of light, and we may add of heat, and probably electricity, are produced by motion among the particles of the ether within the interstices of bodies, which communicates motion to the material atoms of the body itself, and alters their mutual arrangement. On this supposition, there can be no such thing as latent heat, latent light, or latent electricity, any more than there can be latent motion, which is a contradiction in terms. If we suppose light, heat, actinism, and the various forms of electricity, *when developed* in any body to be nothing more than the *motion* of an ether pervading all space, and filling the interstices of every substance, but varying in the length, velocity, and species of its undulations, we may explain by one general hypothesis a vast variety of astonishing phenomena due to agents between which many strong analogies are found to exist. Heat, for instance, is *proved* to be the undulation of an elastic medium, and its rays can be reflected, refracted, polarized, and made to exhibit interference just in the same way as rays of light. In short, there is a high degree of probability that the actinic, calorific, and luminous properties of the sunbeam are due simply to the different *lengths* of the undulations which are transmitted—a *long* wave (comparatively speaking) like the red exhibiting in a marked degree the effects due to *heat*, a *short* wave like the violet those due to *actinism*, and a wave of *medium* length, those due to *light*.

The laws of the reflexion and refraction of light can be easily explained on the undulatory theory, but not without having recourse to a mathematical demonstration which is not sufficiently elementary for the present work. The reader is referred for this demonstration to Professor Airy's Tract, pages 277 to 296, and also to Herschel's "Treatise on Light."

We shall now consider some of the phenomena of POLARIZED LIGHT.

We have said that a ray of common light is composed of undulations which take place in all possible planes passing through the direction of the ray. Now the internal structure of certain substances is such, that when a ray of common light is incident upon them, only the undulations which take place in a *certain plane* or *planes* can be propagated through the substance, and the others are arrested. An instance of this occurs in the case of Iceland spar, the crystals of which are rhombs, and are said to be "doubly refracting."



R*r* is a ray of common light incident at *r* upon a crystal of Iceland Spar. On entering the crystal, the ray is divided into two, and suffers what is called "double refraction." One part of it, *ro* is refracted nearly according to the usual law, and emerges in a direction *oo′*, parallel to R*r*. This is called the "ordinary" ray. The other part of it, *re*, suffers refraction according to a new law, (which is somewhat complicated, and need not be enunciated in this place,) and takes the direction *re*, after which it emerges in the direction *ee′*, parallel to R*r*, the direction of the incident ray. This is called the "extraordinary" ray. It is evident that after emergence the ordinary and extraordinary rays are parallel to one another. On examining their properties by methods which will be described presently, it is found that both the rays *oo′* and *ee′* are what is called "polarized," that is to say, the undulations take place in *one plane only*, the plane of the undulations of the ray *oo′* being perpendicular to that of the ray *ee′*. These planes are called the "planes of polarization," and the rays are called "polarized rays," the term being derived from the idea entertained by Newton, that a ray of light has sides or poles.

In the case of the Iceland spar, *both* the polarized rays are transmitted; but in that of a thin plate of tourmaline, cut parallel to the axis of the crystal, only one of the polarized rays is transmitted; and if this polarized ray be received upon another plate of tourmaline placed parallel to the first as regards its plane, but crossways to the other in that plane, the ray will be altogether stopped. This effect may be popularly explained in the following way:—

A ray of common light, consisting of undulations in all possible planes, is incident upon a plate of tourmaline, which is to all appearance a transparent substance, but its internal structure is such as to resemble the parallel bars of a grating, or wires of a cage. If then we consider the undulations of the ray of common light as taking place upon a number of cards, all passing lengthways through the direction of the ray, it will be only one of these cards that can be pushed between the bars of tourmaline, and the other cards will be stopped. Again, if we receive this one card, which is the polarized ray from the first tourmaline, upon a second plate of tourmaline, with its bars placed crossways to the first, it will be completely stopped; but if the bars of the second tourmaline be placed parallel to those of the first, it will pass through readily enough. This explanation will perhaps convey a sort of popular idea of what is meant by polarized light. A ray of common light may be considered as round, like a ruler; a ray of polarized light as flat, like a riband.

Light is polarized by reflexion as well as by refraction, and all reflecting surfaces have the property of polarizing light more or less, according to the angle at which it is incident upon them. Sir David Brewster discovered that when the tangent of the angle of incidence is equal to the refractive index of the medium upon the surface of which light is incident, the reflected ray is *completely* polarized, and therefore its undulations take place in one plane only. For instance, the surface of plate glass is a reflecting surface, and the refractive index of plate glass is about 1·54, which is the tangent of an angle of 57°. If, then, a ray of common light is incident upon the surface of plate glass at an angle of 57°, it will be completely polarized by reflexion, and the reflected ray will not pass through tourmaline placed in a particular position; nor will it be reflected by another plate of glass placed in a particular position with respect to the first.

Polarized light consists of the same colours as common light, and the waves interfere in the same way. Photographic pictures may be taken by it, although the time of exposure would require to be increased. Photographic experiments with polarized light have not yet, however, received much attention. In the process of copying negatives by light transmitted through them after having suffered reflexion at the surface of a plane reflector, the whole of the light which falls upon the sensitive plate would be polarized if the reflector were placed at a particular angle with the incident rays.

By means of the law of the tangent, discovered by Sir David Brewster, the refractive index of opaque bodies may be ascertained by finding the angle of incidence at which complete polarization by reflexion takes place.

Although the subject of polarized light is one of the greatest interest, yet the scope and object of this work do not permit us to say more about it. The phenomena next to be described are those of INTERFERENCE.

Returning to the figure at page 275.

If we suppose another undulation to be propagated along the line AB, in such a way as to combine with the first, the elevations and depressions of the first would be increased and the effect at the extremity B would be doubled; but if the second undulation were such that its highest point came exactly over the greatest depression of the first, the undulations would exactly counteract each other, and no effect would be produced at B. Between these two extremes there would be of course an infinite number of mean effects, according to the way in which the waves were superposed. In the same way, by letting a stone fall into a pond of still water, undulations are produced; and if a second stone be dropped in the same place, the undulations occasioned by the first may be either increased or diminished, or even altogether destroyed, and smooth water produced, according to the state of the first undulations at the instant of time when the second series were propagated. It would appear, therefore, that two rays of light falling upon the same spot might either produce increased or diminished brightness, or even absolute darkness; and this is found experimentally to be the case. For, let two rays of homogeneous light, red light suppose, emitted from different sources of light A, B, be transmitted through two pin holes in a darkened box, and received upon the same spot, C, of a white screen. If the length of the beam AC be equal to that of the beam BC, or if the difference between AC and BC be any multiple of the length of a ray of red light, *i. e.*, any multiple of ·0000258ths of an inch, the undulations will exactly combine at C, and the intensity of the red spot produced by either ray singly will be doubled. But if the difference between AC and BC be any *odd* multiple of *half* the length of a wave of red light, so that the crest of the undulation of one ray may be superposed on the depression of the undulation of the other ray, darkness will be produced at C. Two rays of light incident upon the same spot may therefore produce darkness, and in the same way two rays of heat may produce cold, and two rays of sound silence. This remarkable effect cannot possibly be explained on the corpuscular theory, for on the theory of the emission of particles, more particles ought to produce more light instead of darkness.

The phenomena produced by the interference of waves of light are among the most beautiful in optics. Nothing can exceed the splendour of the coloured images exhibited in many of the experiments which are illustrative of interference, but in this place we can only briefly allude to the fact that the colours produced by thin films are caused by the interference of the rays reflected from the inner surface of the film, with those reflected from the outer surface, while the iridescence of mother of pearl, and the varied hues of iridescent ornaments, are occasioned by fine lines existing in the surfaces of these bodies, which cause the interference of waves of light. Newton's rings, for instance, and the varied colours of soap-bubbles are produced by interference.

We now pass on to the DIFFRACTION OF INFLEXION of light.

It is assumed in geometrical optics that light can only proceed in a straight line, and therefore that a body which intercepts it must necessarily cast a shadow of definite form, sharp outline, and uniform intensity of blackness. This assumption may have its uses in geometrical optics, but in physical optics it is found to be not strictly correct, for it appears that a ray of light, or line of undulations, is actually bent round the corner, so to speak, in passing close to the edge of an opaque body; so that when an opaque body which intercepts the light proceeding through a small orifice into a darkened chamber is sufficiently narrow, and, at a proper distance from the opening, the rays which are bent round the opposite sides of it interfere and produce alternate bands of light and darkness across its shadow; and in every case, whatever may be the shape or size of the intercepting body, it is found that interfering waves of light produce a series of dark lines and coloured spaces round the edge of its shadow. To explain this phenomenon it is supposed that when light is admitted through a small hole into a darkened chamber, the central rays of the pencil pass straight on and produce a light spot upon the opposite wall, while the undulations which immediately touch the sides of the opening have the property, like those of sound, of communicating undulations obliquely to the ether within the box, and thereby of producing refracted rays which travel with diminished velocities, and, by interfering at the edge of the shadow, produce the dark lines and coloured spaces in question.

It has been thought by some persons that the inflexion of light round the edges of dark objects which intercept it might tend to produce indistinct positives, when these are taken in a copying camera by light which is transmitted through a transparent negative. But this idea is erroneous. We have shown in the article on the "Condenser" that the light parts of a transparent negative which has either the sky, or a luminous background, or a light and condenser, behind it may be considered as made up of a system of bright points, each of which is the origin of a divergent pencil of light so that the bright point immediately adjacent to the edge of any dark part of the negative is the origin of a divergent pencil of light which is refracted by the lens to a focus. Now it is evident that any rays of light which may be bent by inflexion round the edge of the dark part of the negative would only add so many more rays to this divergent pencil, and that the lens would refract them to the same focus as the other rays of that pencil. They could not, therefore, produce indistinctness in the picture. It is important that this should be clearly understood. The indistinctness produced by copying-lenses is occasioned by spherical aberration not being properly corrected in them.

We must now draw to a close our remarks on the interesting subject of the physical nature of light with a few observations on the colour of natural objects, and the theory of the decomposition of light by absorption.

The colour of a natural object (when its surface is not iridescent and the colours produced by interference), is due to its absorbing all the rays of light which fall upon it, and reflecting or radiating only those of its particular colour. The colour of a substance is therefore due to some peculiarity of its structure. A black substance absorbs all the rays of light and reflects none, becoming at the same time heated, or, to speak more correctly, radiating heat rays, which seems to indicate that the absorbed light becomes heat. A white substance, on the contrary, reflects *all* the rays of light, and absorbs none, and does not become heated (comparatively speaking). This again bears out the idea of the conversion of absorbed light into heat.

The reader may enquire what, in general, becomes of absorbed light, or lost light. We cannot do better than quote the following reply of Sir John Herschel to this question:

"The question, 'What becomes of light?' merges in the more general one, 'What becomes of motion?' and the answer on dynamical principles is, that it continues for ever. No motion is, strictly speaking, annihilated; but it may be divided, and the divided parts made to oppose, and in effect destroy one another. A body struck, however perfectly elastic, vibrates for a time, and then appears to sink into its original repose. But this apparent rest is nothing else than a state of subdivided and mutually destroying motion, in which every molecule continues to be agitated by an indefinite multitude of internally reflected waves, propagated through it in every possible direction from every point in its surface on which they successively impinge. The superposition of such waves will, it is easily seen, at length operate their mutual destruction, which will be the more complete the more irregular the figure of the body, and the greater the number of internal reflections."

The theory of the decomposition of light by absorption, brought forward some years ago by Sir David Brewster and since advocated by numerous popular writers, has not been adopted by men of science, but, on the contrary, condemned by Professors Airy, Helmholtz, and others. The idea that the seven colours of the spectrum can be decomposed by absorption into three, viz., red, blue, and yellow, has been shown to be an illogical inference from experiments imperfectly conducted. There must be considered to exist as many different kinds of light as there are different lengths of waves within the limits of the visible spectrum; and when the undulating ether ceases to produce the phenomena of light and colour, its undulations may be called heat, actinism, or as the case may be, according to the effects they produce on grosser matter.

With respect to the chemical action of light, this must be considered as due, in all probability, to the vibratory motions of the ether within the interstices of a body establishing a mechanical disturbance amongst its particles, which either enables or compels them in certain cases to form a new arrangement, or enter into new combinations with each other. By adopting the notion that there is no absolute contact between atoms, and that all bodies are more or less elastic, we can readily imagine that the undulations of the universal ether may act as a mechanical force in promoting chemical combination, or decomposition, determining crystallization, and so on. We need not in this place again enumerate any of the principal phenomena of actinism, these having been discussed at some length in the article on the "Chemistry of Photography," but it may be well to define clearly what the term actinism means. Assuming, then, as highly probable, that the phenomena of heat, light, actinism, and the various kinds of electricity are produced by undulations of the same universal ether, which differ only in the lengths of the waves and the velocities of their propagation, we should define actinism to include all such chemical changes as are effected by waves of ether varying in length between that of a ray of yellow light and of an invisible ray of the greatest ascertained refrangibility. According to this definition, whatever the chemical effects of the red and yellow rays may be, they would be attributable either to heat or light, and not to actinism, for both heat and light are known to produce important chemical changes. But, after all, a definition of this kind is only of use until by some fortunate generalization of causes we are enabled to substitute a better one for it.

The question of "Latent Light" is discussed with that of "Latent Heat;" *q. v.*

LIGNIN; $C_{36} H_{22} O_{22}$. This substance may be considered as a compound of carbon and water. It is of great importance in photography, first because pyroxyline is made from it, and secondly because paper is a nearly pure form of it.

Lignin forms the solid framework of plants. It is obtained in a pure form by removing from saw dust, or any other kind of finely divided woody fibre, all soluble matter, by steeping it in hot and cold water, boiling it in alcohol, water, solution of potass, weak hydrochloric acid, and lastly in distilled water, and then drying the residue at 212°. Or in addition to the above treatment, it may be bleached by chlorine, and rinsed in acetic acid. The cleansed and bleached fibres of linen or cotton, are tolerably pure lignin.

Pure lignin is white, tasteless, and insoluble in water, alcohol, ether, and the oils, or hydro-carbons. Its S. G. is 1·5. When acted on by a cold concentrated solution of sulphuric acid, it is converted into dextrine and grape sugar; cold concentrated nitric acid converts it into xyloidin, having nearly the same properties as that obtained from starch; the continued action of hot nitric acid on it produces oxalic acid; hydrochloric acid blackens, but does not dissolve it, and the acid becomes red or brown; a hot and strong aqueous solution of potass produces oxalate and acetate of potass. It is evident, therefore, that in the process of making pyroxyline by acting on lignin with nitro-sulphuric acid, other compounds may be formed which would in general be injurious in collodion.

Lignin combines energetically with various salts and metallic oxides, and this property is very important in the arts of dyeing and calico printing, in which colouring matters are made to combine with textile fabrics; and also in the preservation of timber from dry rot, and of canvas from mildew, &c. This property lies also at the foundation of the photographic processes on collodion and paper, for had lignin, in its natural form as paper, or in its altered form as pyroxyline, no power of combining chemically with metallic oxides, the photograph would merely lie upon the surface of the film, and could be blown by a breath or removed by a touch from it. It may however be the presence of the organic matter that is necessarily associated with the material of photographs which either causes or assists them to fade.

Wood may be preserved from dry rot by Kyan's patented process of steeping it in a solution of bichloride of mercury; or in one of sulphate of iron, sulphate of copper, or chloride of zinc. The latter salt is especially useful in protecting sail cloth from mildew. Alumina combines energetically with calico and linen, and is much used as a mordant in dyeing.

Woody fibre appears to be permanent in dry air, or completely under water, but not when exposed alternately to the action of air and damp; the ultimate effect of the gradual process of decay being the removal of all the elements but a portion of the carbon from the lignin. Hence it is that some forms of coal, as anthracite, are nearly pure carbon. One of the products of the decomposition of lignin is "fire damp;" another, carbonic acid. The beds of coal in different parts of the world are supposed to have been formed by the decomposition of the forests of monster ferns which at one time covered a large portion of the earth's surface, in all latitudes, before it cooled down to its present temperature, and when its atmosphere was too much impregnated with carbonic acid to be fit for the support of animal life.

LIME-LIGHT. When a jet of mixed oxygen and hydrogen gases is ignited, the flame is scarcely visible, although intensely hot; but by introducing solid matter into it, by causing it to play upon a ball of lime a most intense white light is produced. (*See* "Flame.") This is called the "Drummond light." It is highly actinic, but less so than the light produced by the charcoal points of a voltaic battery. The Drummond light is employed at public institutions for the exhibition of dissolving views, and microscopic specimens. Another form of lime light, invented by Messrs. Horne and Thornthwaite, of Newgate Street, consists in urging a jet of oxygen through the flame of a spirit lamp, and causing it to play upon a ball of lime. The light is very white and intense, although not equal to that of the Drummond light. It is called the "Oxycalcium light;" (*q.v.*) and is very convenient for exhibiting the magic lantern to a small assemblage of spectators as well as in certain photographic operations when conducted by artificial light.

The incandescent lime is gradually dissipated, or sublimed, and the lime ball must be renewed from time to time.

LINE. The one-twelfth part of an inch.

LINSEED OIL. A drying oil, obtained by expressing the seeds of common flax, which yield from 20 to 25 per cent. of their weight.

Its S. G. is ·9395 at 52°. It may be cooled down to 40° without solidifying. It is soluble in 40 parts of cold, and 5 parts of boiling alcohol, and in 1·6 parts of ether. A small quantity of the alcoholic solution is sometimes added to spirit varnishes to diminish their brittleness.

The drying quality of linseed oil is increased by boiling it from three to six hours, and then stirring into it from 7 to 8 hundredths of its weight of litharge; (*q. v.*) In this operation the lead is partially reduced, and a little oleate and stearate of lead are formed, which the oil holds in solution.

A mixture of boiled linseed oil and mastic varnish forms a gelatinous substance much used by artists, and called "Magilp."

Linseed oil is extensively used in paints and varnishes, and also in printer's ink.

LIQUOR AMMONIÆ. Aqueous solution of Ammonia; *q. v.*

LIQUOR POTASSÆ. Aqueous solution of Potass; *q. v.*

LIQUORICE SUGAR. *See* "Glycyrrhizine."

LITHARGE; MASSICOT. Protoxide of lead, Pb. O=112. The "galena," or native sulphide of lead, from which lead is commonly obtained, sometimes contains silver. When this is the case a blast of hot air is passed over the fused mixed metals. This oxidizes the lead, but has no effect upon the silver. The oxide of lead, or litharge, is therefore blown off, and collected in a suitable chamber.

Litharge is a heavy yellow powder, slightly soluble in water, to which it gives an alkaline reaction. It melts at a red heat and tends to crystallize on cooling, but on reaching 212° falls into a powder. When melted it combines energetically with siliceous matter, and would destroy an earthen crucible.

Litharge is much used by painters as a dryer. *See* "Linseed oil." Dark red litharge is called "litharge of gold;" the pale variety, "litharge of silver."

Water which has been filtered through litharge increases the energy of the developer which is dissolved in it, but this should be used immediately, for it will not keep. There is also danger of its producing fog upon the plate.

LITMUS; TOURNESOL; LACMUS. A violet coloured paste, sold in the form of blocks or pyramids. It is made, like archil, by treating certain lichens which grow on rocks by the sea side, in the following manner :—

They are cleaned and ground into a pulp with water; then, ammoniacal liquors from the gas works are added, and the mass frequently stirred and exposed to the air as much as possible. In this way a peculiar colouring matter is produced, which when perfect is pressed out, and mixed with chalk or plaster of paris so as to form a paste. This is the "Archil," of commerce, much used as a purple dye. Another variety, made in the same way in Holland, from the lichens called *Roccella tartarea*, and *Lecanora tartarea*, is called "Litmus." It has a violet-blue colour, is easy to pulverize, and is partially soluble in water, and dilute alcohol, leaving a residuum composed of carbonate of lime, clay, silica, gypsum, and oxide of iron combined with the dye.

The colour of litmus is reddened by acids, and afterwards restored by alkalies. Litmus is much used for making Test-papers; *q. v.*

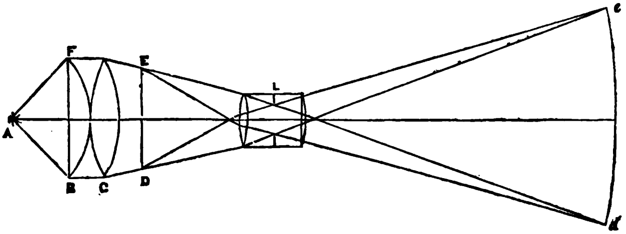
**Logwood.** The heartwood of the *Hæmatoxylon Campechianum*, of the West Indies; brought to Europe in logs about 3 feet in length. The infusion of this wood is of a dark red or purple colour, and is used in dyeing and staining. It gives purples and blues, and also blacks of various intensities by means of iron and alum bases. Its colouring matter is called "Hematin." When chipped logwood is for some time exposed to the air it loses a portion of its dyeing property.

Decoction of logwood absorbs oxygen from the atmosphere, and will then precipitate gelatine, a property which it did not at first possess.

**Lunar Caustic.** Nitrate of silver fused and moulded into sticks. Commercial lunar caustic is sometimes adulterated with the nitrates of potass, zinc, lead, and copper, and should not be used in photography.

**Lutes.** Used for securing the junctions of vessels, and preventing the escape of their contents when submitted to various chemical operations, as distillation, &c. The lutes used for ordinary purposes are slips of bladder, linseed meal made into paste with gum water, albumen and quick lime, putty, and a fat lute composed of pipe clay and drying oil. Windsor loam is used as a lute to withstand a high temperature; this is made by mixing clay and sand into a stiff paste with water. If intended to vitrify, borax or red-lead should be mixed with it.

**Magic Lantern.** An instrument for exhibiting magnified images of transparent pictures upon a screen. The arrangement of the different parts of the apparatus will be understood from the following figure.



A is the source of light; which may be either an argand lamp with a reflector behind it, or better still, a lime-ball rendered incandescent by passing a jet of oxygen through the flame of a spirit lamp, and causing the flame to act upon it. (*See* "Oxycalcium light.") BC are the lenses of the condenser, (*See* "Condenser,") which collect all the rays of light which proceed from the lamp, within the angle FAB, and cause them to converge in such a way as to pass through the transparent picture ED. The front lens FB is plano-convex, the back lens C a "Crossed lens;" *q. v.* ED is the transparent picture, which must be placed in an inverted position. L is a combination of lenses having short negative focal length; and *de* the screen on which the magnified image of ED is received, and rendered visible.

The distance of the slide ED from the lens at L is rather greater than the principal focal length of the combination, and then the screen, which is in the other conjugate focus of the lens, is at a *much* greater distance from it. A pencil diverging from E is brought to a focus at *e*, and a pencil from D at *d*; and so on. The combination of lenses at L which the photographer will find by far the best is the common portrait combination; and when this is used, the posterior lens of the combination should be placed next to the picture, and a stop should be placed between the lenses, as occasion may require. The focus of the condenser should fall pretty nearly on the lens at L which is nearest to the screen.

In order to obtain a perfectly flat field upon the screen, the picture ED should be painted, or photographed, upon a curved surface like a watch glass. (*See* "Micro-photography.")

Magic lantern slides are painted in transparent colours ground in Canada balsam.

Photographic slides for the magic lantern may either be printed upon dry collodionized or albumenized glass plates, by superposition of the negative, or they may be printed by the wet collodion process, by means of a Copying Camera; *q. v.* In this case a little chloride of magnesium added to the iodizing solution is an improvement, for it gives greater vigour and a better colour to the blacks. The glass should be perfectly transparent in the light parts; but stereoscopic slides backed with ground glass may be exhibited in the magic lantern, and produce a tolerably good effect.

Sometimes the screen, or sheet, on which the image is thrown is wetted in order to render it semi-transparent, and the spectators are then placed behind it, and consequently see nothing of the apparatus.

Dissolving views are produced by means of two lanterns, the axes of which are directed towards the same part of the screen, and each of which contains a slide. When a view is to be changed, the cap which closes one lantern is gradually opened, while the other lantern is being shut off. This is done by turning a handle which puts in motion a piece of mechanism contrived for the purpose.

MAGILP. A gelatinous compound made by mixing boiled oil and mastic varnish, in about equal proportions, It is much used by artists for thinning oil colours, and "glazing" on delicate tints in the finishing of the picture.

MAGMA. When a mixture of substances forms a thick pasty mass it is called a "magma."

MAGNESIUM. $Mg. = 12$. A metal, the base of magnesia. It resembles silver in appearance, is hard and malleable, and quickly converted into magnesia by the action of damp air.

MAGNESIUM, OXIDE OF; MAGNESIA. $Mg. O = 20$. A white, heavy, insipid powder, nearly insoluble in water, and having a very feeble alkaline reaction on vegetable colours. It absorbs carbonic acid and water from the air, but these may be driven off again at a red heat. Its salts have in general a bitter taste, and many of them, in particular the chloride of magnesium, and nitrate of magnesia, are deliquescent. The affinities of magnesia for the acids are in general about equal to those of ammonia.

MANGANESE, BLACK OXIDE OF; $Mn. O_2$. This is a mineral which occurs native in Devonshire, Somersetshire, and Aberdeenshire. Its chief, and perhaps only use to the photographer, is as a source of oxygen gas for the oxycalcium light. When heated in a retort to a full red heat it gives off oxygen, and becomes converted into a sesquioxide, $Mn._2 O_3$; it should be well dried before being put into the retort. When added, in the proportion of about one part of black oxide of manganese, to three parts of chlorate of potass, and moderately heated in a retort, over a common fire, oxygen is abundantly given off. The presence of the manganese greatly assists the evolution of oxygen from the latter salt, without appearing itself to undergo decomposition.

*Per* MANGANATE OF POTASS: $K O, Mn._2 O_7$, This salt is easily prepared thus :—

Equal parts of finely powdered black oxide of manganese and chlorate of potass are mixed with one part of caustic potass dissolved in a little water, then evaporated to dryness, and exposed to a temperature just short of ignition. The mass is then treated with hot water, the insoluble oxide separated by decantation, and the deep purple liquid concentrated by heat until crystals form upon its surface. It is then left to cool. The crystals are a deep purple colour and not very soluble in water.

This salt is a powerful oxidizer, and its solution becomes decomposed and decolorized by contact with impurities existing in the atmosphere of towns. (*See* "Sepometer.") It has also been used as a means of testing the comparative stability of positive prints produced by various processes.

MARINE CEMENT; MARINE GLUE. Digest from 2 to 4 parts of india rubber, cut into small pieces, in 34 parts of benzole, and promote solution by heat and agitation. The solution should have the consistence of thick cream. Add to it 62 parts of powdered shellac, and melt the mixture over the fire, stirring it well. Then pour it upon plates of metal, so that it may cool in sheets.

To use it, heat it in an iron vessel to about 250°, and apply it with a brush to the surfaces to be joined.

MARKING INK. First apply the following mordant to the linen :—

| | |
|---|---|
| Carbonate of soda . . . . . | 2 ozs. |
| Distilled water . . . . . . | 1 pint. |

Then write upon it, when dry, with the following ink :—

| | |
|---|---|
| Nitrate of silver . . . . | 1 drachm. |
| Powdered gum arabic . . . | 2 drachms. |
| Sap green . . . . . | 1 scruple. |
| Distilled water. . . . . | 1 ounce. |

Or, the following ink may be applied without a mordant:—

| | |
|---|---|
| Nitrate of silver | 1 ounce. |
| Carbonate of soda | 1½ ounce. |
| Tartaric acid | 2 drachms. |
| Ammonia | 2 ounces. |
| Archil | ½ oz. |
| White sugar | 6 drachms. |
| Powdered gum arabic | 10 drachms. |
| Distilled water | quantum suff. |

Dissolve the nitrate of silver and carbonate of soda separately, then mix, wash the precipitate, put it into a mortar and add the tartaric acid until effervescence ceases. Add the ammonia to dissolve the tartrate of silver, then mix in the other ingredients with the distilled water.

Mastic. A species of resin much used in varnishes. It comes from the Levant, and occurs in small drops or tears of a pale yellow colour, which are the produce of the *Pistacia lentiscus*. It contains about 90 per cent. of a resin easily soluble in alcohol (masticic acid), and a viscid and difficultly soluble resin.

Matches, Congreve, or Lucifer. Make the following ingredients into a paste with water, and dip the matches into it:—

| | |
|---|---|
| Gum arabic | 16 parts |
| Phosphorus, powdered | 9 „ |
| Nitrate of potass | 14 „ |
| Black oxide of Manganese | 18 „ |

Measures. *See* Tables at the end.

Melting Point of Metals. The following table is extracted from "Turner's Elements of Chemistry":—

| | | Fahrenheit. |
|---|---|---|
| Fusible below a red heat, or 980°, the heat of a common fire being about 1200°. | Mercury | −39° |
| | Potassium | 136° |
| | Sodium | 190° |
| | Tin | 442° |
| | Cadmium | 450° |
| | Bismuth | 497° |
| | Lead | 612° |
| | Zinc | 773° |
| | Antimony | — |
| | Silver | 1873° |
| | Copper | 1996° |
| | Gold | 2016° |
| | Cast Iron | 2786° |

Cobalt and nickel are rather less fusible than iron.

Platinum and chromium are only fusible before the oxyhydrogen blow-pipe. The same may be said of most of the very scarce metals.

**Mercury**; Hg.=100. A white metal, fluid at ordinary temperatures, and solid at −40°. It boils and becomes vapour at 660°, and emits vapour at all temperatures above 40°. The principal ore of this metal is the sulphide, or native *cinnabar*.

Perfectly pure mercury may be agitated in contact with air, oxygen, hydrogen, nitrogen, carbonic acid, and alcohol; but when impure it becomes coated with a grey powder, which is a mixture of the oxide of the foreign metal and finely divided mercury. On the other hand, when mercury is agitated with water, ether, or oil of turpentine, it is reduced to grey powder, which is composed of minute globules of mercury blended with the foreign body.

Mercury combines with several of the metals, and forms "amalgams."

**Mercury, Oxide of.** There are two oxides of mercury, viz., the black, $Hg._2$ O, and the red, Hg. O. Both are salifiable. The black oxide is reduced by light into Hg. and Hg. O. The red oxide becomes black when heated, but red again on cooling. It is superficially reduced by light, and becomes black. These oxides form a great number of curious and important salts.

**Mercury Bath.** The box in which daguerreotypes are developed by the fumes of mercury. It should be made of iron, in the form of an inverted pyramid, provided with a thermometer, and supported upon an iron stand. The plate should be placed horizontally over the mercury. This form of apparatus was first used in America, and may now be seen at most photographic depôts in this country. It is very simple and inexpensive,

**Metagallic Acid.** An organic substance formed by the oxidation of gallic acid. It combines with oxide of silver, and other metallic oxides, and displaces carbonic acid from the alkaline carbonates. It is produced by rapidly heating gallic acid up to 480°, when carbonic acid and water are evolved, and metagallic acid remains as a black shining substance, insoluble in water, alcohol, and ether. Its equivalent is supposed to be $C_{12}\ H_3\ O_3$, HO.

**Metagelatine.** When a strong solution of gelatine has been boiled and cooled several times it ceases to gelatinize on cooling, and remains fluid. In this state it is called metagelatine, and may be used successfully as a preservative substance in the collodion process. It is a much less powerful reducing agent than honey, and therefore less likely to fog the collodion plate.

The mode of preparing metagelatine, originally described by Mr. Maxwell Lyte, is as follows:—

Dissolve 1½ ounce of pure white gelatine in 10 ozs. of boiling water. Add 60 minims of strong sulphuric acid diluted with 2½ ozs. of distilled water. Boil for five minutes, and then let the liquid cool. Then boil it again for five minutes and let it cool. Should it still gelatinize on cooling, repeat the operation. When it remains fluid on cooling, neutralize the acid with powdered chalk, and remove the insoluble sulphate of lime by squeezing the mixture through a cloth.

Metagelatine dries to a hard transparent film upon the collodion. When intended to be used as a moist preservative, a little golden treacle, (not honey nor glucose,) should be added to it.

METHYL. Me. (Greek, μεθυ wine, and ὑλη wood.) A hypothetical substance, the composition of which is assumed to be $C_2 H_3$, and which forms the supposed base of a series of methyl compounds analogous to those of ethyl.

METHYLIC ETHER. Me. $O = C_2 H_3 O$. When equal parts of "wood alcohol," (or "pyroligneous spirit," as it is termed,) and sulphuric acid are distilled together, a gas is evolved, which, when collected over mercury and purified by potass, is found to consist of oxide of methyl, or methylic ether. It has an etherial odour, with a taint resembling peppermint, and may be taken up abundantly by alcohol, or wood-alcohol, or ether.

METHYLIC ALCOHOL. Me. $O + H O = C_2 H_3 O + H O$. This substance, called "wood alcohol," or "pyroxylic spirit," is a hydrated oxide of methyl, and analogous to the alcohol of the ethyl series. It is one of the products obtained from the distillation of wood. In its properties it greatly resembles alcohol, and as there is no duty on it, it is much used as a solvent for varnishes, &c. Its taste is hot and pungent; S. G. ·800; it boils at 150°, at the mean pressure of the atmosphere; mixes in all proportions with water, alcohol, and ether; and is neutral to test paper.

According to an excise regulation, when ordinary alcohol is mixed with 10 per cent. of wood alcohol, it is sold free of duty, under the name of "methylated spirit."

Methylated spirits are extensively used in the manufacture of collodion, on account of the heavy duty on ether and alcohol. It is probably due to the variable quality of these spirits that so much bad collodion finds its way into the market.

MICA. A transparent mineral, of a pearly lustre, mostly brought from Siberia. It may be divided into sheets, which are hard and flexible. It is an ingredient of granite and gneiss.

MICRO-PHOTOGRAPHY. Under this head may be included two different processes. One is of little or no practical utility, and consists in copying objects on an exceedingly small scale, the photograph being intended to be viewed through a magnifier, or microscope. The other, which is a branch of photography of the highest interest and importance, consists in producing enlarged photographs of minute objects—that is, in fixing the images obtained in the microscope.

With respect to the former of these two processes, a few words will suffice. In order to obtain an extremely minute image of an object, it must either be placed at a much greater distance than usual from the lens, or a lens of very short focus must be used. Any of the ordinary forms of photographic lens may be made of one inch focal length, and then by placing the object or group to be copied at a suitable distance, a photograph may be obtained in a drop of collodion. The only difficulty in the process is that of focussing. This may be done on the sensitive film itself, a yellow glass being interposed between it and the lens while focussing, and a powerful magnifier employed to examine the focus. Negatives may, of course, be copied either by transmitted natural or artificial light. Enough has now been said about a process which must strike any reasonable person as somewhat trifling and childish, when he considers how many valuable applications of photography remain yet to be worked out.

The copying of magnified images in the microscope, in such a way as to satisfy sound criticism, is a matter of much greater difficulty. The principle of the thing is simple enough, and will be understood by reference to Fig. 6, page 63, in which P Q may be considered a microscopic object, and *p q* its magnified image; but the difficulty consists in obtaining a flat field when the ratio between the size of the image and the object is considerable. In the low-power lens of an ordinary microscope this ratio is as 8 : 1; and the size of the field about 1·4 inches. By using a lens of double the focal length, and removing the object to double the distance from it, a picture of the same size is obtained, the lateral pencils have less obliquity, and the field is much flatter, but the amount of light is reduced to one fourth. It is evident, therefore, that the optical difficulties are diminished by increasing the intensity of the light. It would be well, therefore, to perform micro-photographic operations by sunshine transmitted through the object by means of a reflector and condenser; or else with the Bude light. A great amount of solar light is, however, accompanied with great heat, and a difficulty is introduced from this cause. The photographer has, however, two other resources. He may either work upon plates which are ground spherical, like a watch glass; or the object itself may be inclosed between curved glasses. The former plan would probably be found the best.

With respect to the best form of lens. There is an erronous impression afloat among amateur microscopists who know but little of optics, that the obliquity of the pencils when high powers are used is something considerable, and that modern science has brought under its control the various vagaries of oblique pencils. This is not the case. The vagaries of oblique pencils are incurable, and like the quadrature of the circle they set at defiance all the resources of the mathematician. The truth is, the obliquity of the lateral pencils in the microscope is inconsiderable compared with that of the lateral pencils in an ordinary camera obscura. The best form of lens for obtaining micro-photographs is therefore an achromatic single lens, as represented in Fig. 6, and constructed on a similar principle to the object glass of the telescope. By increasing the number of lenses, light is lost, and distortion introduced.

The principles of this branch of photography having been now, it is hoped, clearly explained, the various modes of applying them may be left to the ingenuity of the reader.

MILK. The milk of different animals does not appear to vary much in composition. It is composed of three principles, viz., butter, cheese, (or *casein,*) and whey, (or *serum*).

When examined under the microscope milk appears as a transparent fluid in which small white globules are diffused. These rise to the surface when the milk is left at rest, and form cream, which may be removed by skimming. The globules are supposed to be the butter contained in small membranous bags, which are broken by churning. Ether has at first no effect upon these globules, but the membrane is soluble in acetic acid, and when dissolved the butter is liberated and ether readily takes it up.

Casein is a substance resembling albumen in its properties. It is soluble in an alkali, and may be coagulated by an acid. *See* "Casein."

Serum or Whey is the watery matter of milk. It contains a sugar called Sugar of Milk, *q. v.*, and also various salts.

Milk contains about 14 per cent. of butter, 14 per cent. of casein, and the remainder whey. It is either neutral or slightly alkaline, but quickly becomes acid by exposure to air, from the formation of lactic acid.

Both casein and whey are useful in photography, but milk should not be used in any process until the cream has been completely removed by skimming. Curd or casein is produced by adding an acid, or better still a piece of rennet, to fresh milk. *See* "Rennet."

MINIUM. Red Lead; *q. v.*

MORDANT. A class of substances used in dyeing, their effect being to cause the dyeing material to combine with the fabric to which it is applied, so that it cannot be removed by simple washing, or any ordinary treatment. Mordants are in general metallic oxides which have an affinity for the organic matter of the stuff, and by combining with it, cause the particles of the dye to combine also, and form a species of triple compound. The mordant most likely to be useful in photography is bichromate of potass when reduced by light. This enters into powerful combination with lignin, and takes down with it any particles of carbon, or pigment, or colouring matter that are mixed with the bichromate. In this way textile fabrics may be printed by photography.

MÖSER'S IMAGES. M. Ludwig Möser has described at different times in "Poggendorff's Annalen," a variety of curious experiments in which images were obtained by contact and developed by vapours in a similar way to the images in the process of Daguerre. From these experiments he has drawn certain conclusions, which are generally supposed to be erroneous. For an account of them the reader is referred to "Hunt's Researches on Light," page 248. Mr. Grove, and Professor Volpicelli have also obtained latent images capable of being developed by vapours, by means of contact aided by electricity. The account of these experiments will be found in the 2nd volume of "Photographic Notes," edited by the author. This subject is one of great interest, and no doubt intimately connected with photography; it is however at present involved in so much obscurity, that we think it better to refer the reader to other sources of information than to occupy space in this work with more than a brief notice of it.

MOUNTING PRINTS. This consists in attaching the print, either entirely, or by its edges, to a sheet of cardboard, by means of an adhesive cement.

Of all adhesive substances, starch appears to be the most suitable. It should not be made too thick, and after being boiled should be strained through a cloth, and used quite fresh, as sour starch would be certain to cause the fading of the print.

The face of the cardboard is first damped with a moist sponge, to cause it to expand in the same degree as the print when the starch is applied to it. If this be not done, the print contracts on drying, and draws the cardboard out of shape. The print is then laid with its face upon a slab of glass, and the starch spread thinly and evenly upon the back with a stout hog-hair paint-brush. The print is then applied carefully to the damp cardboard, and lightly pressed into contact, and air bubbles pressed out, with a linen rag. A sheet of cardboard is then laid upon it, and the rag rubbed over this pretty forcibly in order to ensure the perfect adhesion of the print to the mount in every part. The cardboard upon which the print is mounted is then pinned up by one corner to dry, and afterwards placed under a book-binder's press, or a board loaded with weights.

French cardboard is mechanically the best for the purpose, and the thicker it is the easier the operation becomes; but the bluish tint of French cardboard is very objectionable, as it contrasts disagreeably with the tint of most photographs. Cream colour is far better; and there is no doubt that cardboards might be manufactured of a great variety of suitable tints, and that the general effect of photographic prints would be greatly improved by being mounted upon such. Stereoscopic subjects should be mounted upon cardboards nearly if not absolutely black; and collodion positives on paper either upon gilt or deep purple cardboard. As a general rule a photograph should never be contrasted with anything absolutely white, or what is even worse, of a bluish white like French paper.

MURIATIC ACID. *See* "Hydrochloric acid."

NAPHTHA; ROCK OIL. $C_6 H_5$. A combustible and volatile liquid, resembling oil of turpentine. It occurs naturally, and may also be made artificially. As a natural product it exists in the soil at Baku, on the north east shore of the Caspian, at Amiano in the duchy of Parma, at Zibio in the duchy of Modena, at Neufchatel in Switzerland, at Clermont in France, at Val di Noto in Sicily, at Trinidad, Barbadoes, Rangoon, &c. The naphtha of commerce comes mostly from Trinidad. As an artificial product it is obtained from the distillation of petroleum, or the coal-oil of the gas works.

The S. G. of Persian Naphtha is about ·775, of coal naphtha about ·820.

Naphtha does not congeal at 0°; it is not soluble in water, but communicates a smell and taste to it; it dissolves in absolute alcohol, ether, and oils, and is a solvent of the resins, as well as of phosphorus and sulphur in small quantities. It softens and gelatinizes india rubber, and this glairy varnish is spread upon textile fabrics to render them waterproof.

The boiling point of naphtha is about 320°. It is not acted on by potassium and sodium, and is used for preserving those highly oxidable metals from the action of the air.

The naphtha above described is sometimes called *mineral* naphtha to distinguish it from wood alcohol or "wood naphtha," which is a totally different substance.

Naphtha may be economically used for burning in spirit lamps.

**Natural Colours.** To obtain photographs in the natural colours is, of course, a grand problem; but the probability of its ever receiving a solution is, in our opinion, very small; and, so far as we can see, nothing has yet been done to inspire a hope that it may ever be accomplished. The different colours produced upon various sensitive tablets by coloured images seem, in every case, to arise from the different state of decomposition of the sensitive material by different degrees of actinic power in the light which do not correspond with the different tints of the natural colours.

In order to produce a photograph in the natural colours, the coloured image formed in the camera must be received upon a tablet so constituted as that every colour may, where it acts, produce such an effect as that when the tablet is afterwards exposed to white light the same coloured rays may be emitted at the particular spot impressed. To discover the means of producing such a tablet really seems to be hopeless, although certainly not impossible.

We refer the reader to a pamphlet published by Mr. Thomson, (of Messrs. Ross and Thomson, Edinburgh) for particulars of various experiments which have been made by different persons with the view to the discovery of photography in the natural colours.

**Negative.** A photograph in which the lights and shades are reversed, and the opposite of those in nature, is called a "negative."

The value of a negative consists in the means it affords of multiplying positive prints in which the lights and shades are true to nature. The best negatives are those which are taken upon glass coated with a uniformly transparent and structureless film of collodion, albumen, &c.; but as glass is a costly, heavy, and fragile substance negatives are sometimes transferred from glass to a film of gutta percha; and are frequently taken upon paper, waxed in order to render it more evenly transparent. For a certain class of bold artistic subjects paper may be considered suitable.

The various negative processes upon collodion, albumen, paper, &c., are described under their respective heads.

NITRATE OF AMMONIA. $NH_4 O, NO_5$. This salt is obtained by neutralizing ammonia, or carbonate of ammonia, with dilute nitric acid, evaporating and crystallizing. At 228° it fuses; at 356° boils, without decomposition; and at 400° is decomposed into nitrous oxide, (laughing gas,) and water. It is slightly deliquescent, and soluble in rather more than its own weight of water, and in about six times its weight of alcohol. It is much used in making freezing mixtures.

Nitrate of ammonia is not a stable salt, for it parts with ammonia to the air, and becomes acid with free nitric acid. When the haloid salts of ammonia are used in photography, nitrate of ammonia is formed in the nitrate bath, and hence arises the danger of the bath becoming acid with free nitric acid, from the escape of the ammonia. Nitrate of ammonia is a solvent of oxide of silver; and this constitutes another objection to the use of the ammonia salts in the negative processes.

NITRATE OF BARYTA. $Ba. O, NO_5$. This salt is formed by dissolving the native carbonate of baryta in dilute nitric acid, evaporating to dryness, redissolving and recrystallizing. It is permanent, and anhydrous; soluble in 12 parts of cold, and 4 parts of boiling water, and insoluble in alcohol. It is decomposed at a red heat, and yields pure baryta.

Nitrate of baryta is used in making a good iron developer for collodion positives. If dissolved in hot water the solution must be allowed to get quite cold before being added to the iron salt.

NITRATE OF CADMIUM. $Cd. O, NO_5 + 4\,HO$. This salt is deliquescent, and soluble in alcohol. It has an acid reaction, and its accumulation in the nitrate bath, when iodide and bromide of cadmium are used in the iodizing solution, is highly injurious in the negative process, by destroying the sensitiveness of the film, and rendering the image thin and metallic, while in the positive bath it is liable to fog the plate.

Nitrate of Iron. There are two nitrates of iron, the protonitrate, and the pernitrate. The protonitrate is a deoxidizing substance, obtained in solution by mixing solutions of protosulphate of iron and nitrate of baryta, according to their equivalent proportions. This solution is decomposed at a boiling temperature, and becomes converted into pernitrate of iron by long exposure to air.

Protonitrate of iron is used either alone, or in conjunction with protosulphate of iron, as a developer of collodion positives. It is not an energetic developer, and when used alone renders the whites of the image too metallic.

Pernitrate of iron is a reddish brown deliquescent substance, soluble in water and alcohol, and decomposable at a red heat.

Nitrate of Lead. Pb. O, $NO_5$. A white, anhydrous salt, obtained by acting on litharge with hot nitric acid diluted with 2 parts of water, (the litharge not being in excess,) evaporating and crystallizing. It is soluble in 8 parts of water, and insoluble in alcohol.

When nitrate of lead and litharge, in equal weights, are boiled together in water, and the solution filtered and crystallized, white crystals are formed of subnitrate of lead, which are nearly insoluble in cold water.

Nitrate, or subnitrate of lead, added to the negative nitrate bath has been supposed to render the process more sensitive. In the positive collodion process a tolerably good developer may be made by substituting nitrate of lead for nitrate of baryta.

Nitrate of Magnesia. This salt is deliquescent, soluble in an equal weight of water, but nearly insoluble in alcohol. It has an acid reaction, and therefore renders the nitrate bath slightly acid when iodide or chloride of magnesium are used in the iodizing solution. From its deliquescent properties, solution of nitrate of magnesia has been used as a means of preserving the moisture of the sensitive collodion film, but not with much success.

Nitrate of Potass; Nitre; Saltpetre. KO, $NO_5$. This important salt is obtained in India in large quantities, but in an impure form, by lixiviating certain soils; and in France, and other countries, it is obtained from old mortar rubbish, in which organic matter has supplied the nitrogen wherewith to form nitrate of lime, which is then decomposed by carbonate of potass.

Pure nitre is not rendered turbid, when in solution, either by nitrate of silver, or nitrate of baryta. It crystallizes in long six sided prisms, and is anhydrous, the moisture of the crystals being merely interstitial. They are permanent in the air. Nitre is soluble in about 4 parts of water at 60 and in equal parts of boiling water, but is nearly insoluble in alcohol; it fuses at 600 without decomposition, and at a red heat is slowly decomposed and yields oxygen, 1lb. of nitre giving off about 12,000 cubic inches of gas.

Fulminating powder is made by mixing 3 parts of nitre, 2 of dry carbonate of potass, and 1 of sulphur. If a small quantity of this mixture be placed upon a shovel over the fire, it first melts and blackens, and then explodes with violence.

Gunpowder is made by mixing 1 part of charcoal, 1 of sulphur, and 6 of nitre, all in fine powder.

The principal impurities in nitre are the chlorides of sodium and potassium, sulphate of potass, and nitrate of soda.

Nitrate of potass added to protosulphate of iron forms a tolerably good developer for collodion positives, but nitrate of baryta is better, because sulphate of baryta is insoluble, and may be separated from the solution, which sulphate of potass cannot.

Pyroxyline is sometimes made by adding nitrate of potass to sulphuric acid, instead of mixing the sulphuric and nitric acids. The plan is not good, because it is extremely difficult to remove the whole of the bisulphate of potass which is formed from between the fibres of the pyroxyline with which it is entangled.

The nitrate of potass formed in the nitrate bath when iodide of potassium is used as an iodizer, is neutral, and appears to be inert in the process.

NITRATE OF SILVER. $Ag. O, NO_5 = 170$. This is one of the most important salts at present used in photography. It is obtained in its purest form by dissolving pure silver in pure nitric acid, S. G. 1·25,, evaporating and crystallizing, and then redissolving and recrystallizing. The salt is then neutral to test paper. Commercial nitrate of silver is made by dissolving silver coins, or silver plate, in nitric acid, evaporating and crystallizing, washing the crystals with nitric acid, and then redissolving and recrystallizing. The alloy of copper and other metals is not completely got rid of in this way. Commercial nitrate of silver is sometimes adulterated with the nitrates of potass, zinc, lead, &c. Impure nitrate of silver is one of the greatest evils with which the photographer has to contend, and his best remedy is to precipitate the chloride by adding salt to the solution of impure nitrate, then to reduce the chloride, by fusion in a crucible with twice of its weight of carbonate of soda, to a button of pure metallic silver, and redissolve this in pure nitric acid.

Nitrate of silver crystallizes in large, flat, nearly transparent, four or six sided tables. It is soluble in about an equal weight of cold water, and in four times its weight of boiling alcohol, but sparingly soluble in cold alcohol. It is anhydrous, and may be fused and run into moulds. It is slightly deliquescent in moist air. Its solution is perfectly colourless; and neither the crystals nor the solution are affected by light, unless organic matter be present. It is a powerful caustic, in consequence of its ready decomposition by organic matter; and therefore highly poisonous, salt being the best antidote.

It has been recommended to use fused nitrate of silver in photography, because all the free nitric acid which it may contain is driven off by the heat in the process of fusion; but this is a bad plan when the nitrate of silver is adulterated with nitrate of potass, because nitrite of potass is first formed by heat, and this becomes oxidized at the expense of the nitrate of silver, and forms nitrite of silver, a most injurious substance to introduce into a nitrate bath. Fused nitrate of silver is generally alkaline, probably because some oxide is formed which is combined with the nitrate; the alkalinity should be neutralized with *acetic* acid for a negative bath. Fresh *distilled* water should always be used for dissolving nitrate of silver, as pump or river water contain salts which produce a cloudy precipitate with it. Rain water collected in leaden tanks should on no account be used, as it contains oxide of lead in solution, which is very likely to fog the negative. (*See* " Leaden Tanks.") Nitrate of silver may easily be fused in a porcelain capsule over a spirit lamp.

If a piece of copper be suspended in a solution of nitrate of silver, the silver is precipitated in beautiful crystals; but a piece of polished iron or steel is not acted on. A little mercury poured into the solution occasions the precipitation of crystals in the form of a shrub, called the *Arbor Dianæ.*

NITRATE OF URANIUM. There are two nitrates of this metal, the protonitrate, UO, $NO_5$, and the pernitrate, or nitrate of the sesquioxide, $U_2$ $O_3$, $NO_5+6$ HO. The latter is the common crystallized salt, obtained by dissolving any of the oxides of uranium in nitric acid. It forms yellow prisms, which are efflorescent, and fuse in their water of crystallization. It is very soluble in water, alcohol, and ether. By exposure to light it is reduced to the protonitrate.

NITRATE OF ZINC. A deliquescent salt, having an acid reaction. It has been used as a means of preserving the moisture of sensitive collodion plates, but the plan does not seem to answer.

NITRATE BATH. Many of the failures in photographic operations, particularly in the negative collodion process, may be traced to the nitrate bath being out of order.

1st. It may not be of the right strength. Test it with the silver meter (*q. v.*), and add either water or nitrate of silver, as the case may require.

2nd. It may be alkaline to test paper. To a *negative* bath add *acetic* acid, a drop or two at a time, until acidity is established. To a *positive* bath add *nitric* acid. The bath becomes alkaline in consequence of the introduction of carbonate of potass, an impurity contained in iodide of potassium. An alkaline bath fogs the plate, and gives a very dense picture.

3rd. It may be too acid. This diminishes the sensitiveness of the film, and in the case of acidity from nitric acid produces grey metallic negatives devoid of density, and brings about by great over-exposure the reverse action of light. In the case of a great excess of acetic acid, the negatives are all black and white, and devoid of half-tone. Acidity keeps the lights clean and transparent. It is brought about either by the fermentation of the ether and alcohol which are continually added to the bath, or by the accumulation of an acid salt, such as nitrate of cadmium. The remedy for excess of nitric or acetic acid is carbonate of soda. Add a solution of this, a few drops at a time, until the bath is rendered alkaline, then acidify slightly with acetic acid, and filter. The addition of carbonate of soda produces a yellow turbidity, due to carbonate of silver; when acetic acid is added acetate of silver is formed, and carbonic acid liberated; the acetate of silver is, for the most part, dissolved in the nitrate bath, the remainder is removed by filtering. The shaking of the bath in travelling frequently renders it acid by causing the fermentation of the organic matter.

4th. The picture may be fogged all over, and yet be thin and grey, and the bath acid. This state of things is not so easily explained, nor is it easy to suggest a certain remedy. A plan which frequently answers is to add *nitric* acid, and let the bath stand for a day or two, then to neutralize with carbonate of soda, and acidify slightly with acetic acid.

Sometimes a bath in this state is cured by exposing it for a day or two to sunshine, and thus throwing down a deposit of silver and organic matter.

Another plan is to add a solution of carbonate of soda to the nitrate bath until the whole of the silver is thrown down as yellow carbonate of silver. This should be allowed to settle and the clear liquid poured off. The carbonate should then be well washed in several waters, dried, and roasted in a crucible; after which it may be dissolved in nitric acid, which liberates the carbonic acid and produces nitrate of silver;—or if the presence of lead be suspected, acetic acid may be added, which forms insoluble acetate of silver and soluble acetate of lead; the acetate of silver must then be well washed and lastly dissolved in nitric acid, and the nitrate of silver solution evaporated and crystallized.

Or, instead of throwing down the silver as a *carbonate*, it may be precipitated as an *oxide*, by adding solution of caustic potass. The oxide should then be treated in the same way as the carbonate.

The advantage of either of the above methods is that it separates the silver from the excess of nitrates which may have accumulated in the bath.

Sometimes a bath may be cured by simply evaporating, crystallizing, and redissolving the nitrate of silver in pure distilled water.

Nitric acid is an infallible remedy for nitrite of silver in a bath.

A nitrate bath is frequently put out of order by dirty plates being immersed in it.

Ammonia should never be added to the nitrate bath for negatives. A *fixed* alkali is far better.

NITRIC ACID. $NO_5=54$; or in its hydrated state, $NO_5\ HO$.

Nitric acid may be obtained by passing electric sparks through a mixture of 7 volumes of oxygen and 3 of nitrogen. Hence the explanation of the occurrence of nitric acid in rain water during thunder storms. The commercial red fuming nitric acid is manufactured by distilling two parts of nitrate of potass with one of sulphuric acid; 112lbs. of nitre and 56lbs. of sulphuric acid yielding about 50lbs. of nitric acid; the proportions admit, however, of variation. The red colour and fumes are due to peroxide of nitrogen.

Nitric acid has been obtained in an anhydrous state by a complicated process. It is a white solid. The liquid acid, in its more concentrated form, has a specific gravity 1·5, and consists of 1 equivalent of anhydrous nitric acid and 1½ of water.

Concentrated nitric acid does not act on copper, tin, or silver, without the addition of water, which is decomposed and oxygen furnished to the metal. When the metal is oxidized the nitric acid converts the oxide into a nitrate.

Nitric acid is a powerful oxidizing substance, and acts energetically upon organic matter; also upon phosphorus, sulphur, and carbon with the aid of heat.

*All* the salts of nitric acid are soluble in water, and most of them are neutral. They are, in general, decomposed by sulphuric acid aided by a gentle heat. There are no double nitrates, nor any nitrates with excess of acid. The principal impurity in nitric acid is sulphuric acid.

NITRITE OF SILVER. $Ag.O, NO_3=154$. This salt is obtained by fusing together equal parts of nitrate of potass and nitrate of silver. Oxygen is driven off from the former, which is converted into nitrite, and this again acquires oxygen by converting the nitrate of silver into nitrite. By dissolving the mixture in a small quantity of boiling water the nitrite crystallizes out on cooling. The crystals are long slender needles, soluble in 120 parts of water at 60°. This salt is easily decomposed by a strong acid. When present in a nitrate bath it fogs the picture.

NITRO-HYDROCHLORIC ACID; AQUA-REGIA. A mixture of two parts of hydrochloric acid, and one part of nitric acid. This mixture dissolves gold, hence its name. Common salt added to nitric acid, or nitre to hydrochloric acid, have the same property. The rationale of the process appears to be, that nitric acid plus hydrochloric acid produces chlorine, nitrous acid, and water. The chlorine dissolves the gold.

NITROUS ACID. $NO_3$. This acid is by some chemists called hyponitrous acid. It is not easily isolated. It forms salts called nitrites, none of which have any interest in photography except the nitrite of silver; *q. v.*

NITROGEN. $N=14$. An elementary gas. It is obtained by burning phosphorus in a closed vessel containing air, and passing the gas through lime water; or by agitating a liquid amalgam of lead and mercury with air in a closed vessel for two or three hours, when the lead abstracts the oxygen. It has neither smell nor taste, nor any action upon vegetable colours; nor is it a supporter of combustion. Atmospheric air contains principally 1 atom of oxygen to 2 of nitrogen, in a state of mixture, not combination. Nitrogen is a little lighter than air.

**Nitrogen, Oxides of.** There are 5 oxides of nitrogen, viz:—

| | |
|---|---|
| Nitrous oxide, (laughing gas) | $NO$ |
| Nitric oxide, (binoxide of nitrogen) | $NO_2$ |
| Nitrous acid | $NO_3$ |
| Peroxide of nitrogen | $NO_4$ |
| Nitric acid | $NO_5$ |

**Nitrogen, Peroxide of.** $NO_4$. When two volumes of binoxide of nitrogen ($NO_2$) are mixed with one of oxygen, in an exhausted vessel, they combine with the evolution of heat, and form vapour of peroxide of nitrogen. This condenses into a liquid at 0°, and crystallizes at a lower temperature. The liquid is pale yellow at 32°, and deep orange at 60°; it boils at 82°; and when exposed to the air at common temperatures evaporates in yellow fumes. It is produced in nitric acid by exposure to light.

The vapour of peroxide of nitrogen is composed of 1 volume of nitrogen and 2 volumes of oxygen, condensed into one volume.

**Nitro-Glucose.** This substance is made by acting on finely powdered cane sugar with nitrosulphuric acid; the proportions being 2 ounces sulphuric acid, 1 ounce nitric acid, 1 ounce cane sugar. The pasty mass at first formed is stirred for some minutes, and it then separates from the liquid in lumps. When these are kneaded in warm water until the acidity is removed, they acquire a white and silky lustre.

This organic substance, when added in very small quantity to collodion, increases the density of the negative, and renders the film less sensitive to light.

**Noble Metals.** Gold, platinum, silver, and a few other metals, are called "noble metals," on account of their feeble affinity for oxygen, for they may remain in fusion for many hours in contact with air without becoming oxidized.

**Non-reversing Slide.** This is a camera slide, so contrived that collodionized glass plates may be exposed in it with the back of the plate next to the lens, and the film next to the back shutter. The best plan is to make an ordinary slide deep enough to hold two glass plates, with a space at least equal to the thickness of a plate between them; a glass plate is then to have a small triangular piece of glass cemented to each corner; the collodionized plate is laid, film upwards, in the slide, and the other plate laid with the corners upon it; the back shutter is then closed with its spring pressing against the upper plate.

A non-reversing slide should always be employed for taking collodion positives, and also for negatives when the prints are intended to be viewed in the reflecting stereoscope.

NORMAL. The normal to a surface at any point, is the straight line perpendicular to the tangent plane at that point.

OBJECT GLASS. In a telescope, or microscope, the glass placed next to the object to be viewed is called the "Object glass." The arrangement of lenses at the opposite end of the instrument, through which the spectator looks, is called the "Eye Piece." The glass next to the eye is called the "Eye Glass;" and that next the object glass the "Field Glass."

In an astronomical telescope, or compound microscope, there are only these three lenses.

OILS. Oils are divided into two great classes, viz., Fixed, and Volatile, (or essential.)

The FIXED oils are distributed largely through the animal and vegetable kingdoms. In the former the fatty matter is enclosed in membraneous cells existing in various parts of the body of the animal; in the latter they are obtained by expression from the seed, kernel, root, bark, and other parts of plants. Fatty substances may be classified under the heads of Stearine and Oleine, the former *solid* and resembling suet, the latter *liquid* at ordinary temperatures. They may be again classified according to their property either of *drying*, or becoming *rancid* by exposure to air and light. Most oils, whether fixed or volatile, absorb large quantities of oxygen by exposure to air and light;—in the case of drying oils the effect produced is the formation of a skin or resinous varnish;—in the other case the oil is decomposed and becomes rancid and acid. Drying oils are much used in paints and varnishes. *See* "Drying Oils."

VOLATILE oils are contained principally in various parts of odoriferous flowers, and shrubs. They are obtained in general by distillation of the dried leaves, &c. with water, and sometimes with salt and water, which raises the boiling point. The volatile oil and steam go over together, and when condensed in the receiver, the oil in most cases separates and floats upon the surface of the water. A small quantity is also dissolved in the water, to which it communicates its peculiar smell. Rose water is an instance of this. A drop of fixed oil leaves a permanent stain upon paper, a drop of volatile oil does not. Volatile oils are mostly soluble in alcohol, fixed oils are not; both kinds are, however, freely soluble in ether. When water is added to a mixture of a volatile oil and alcohol it renders it turbid. The odoriferous spirits called "Lavender water," "Eau de Cologne," "Eau de jasmine," &c. are solutions of a volatile oil in alcohol. Volatile oils combine with acetic and oxalic acid; but with the exception of oil of cloves, they do *not* combine with alkalies to form soaps. They dissolve all the fat oils and the resins.

Oils are supposed to be compounds of an organic acid with glycerine as a base. When an alkali is added to the fixed oils, at a boiling temperature, the glycerine is displaced and the new compound formed is soap. Oils contain a large quantity of hydrogen. Fixed oils are bland and mild to the taste, volatile oils acrid and nauseous.

OLEFIANT GAS. $C_2 H_3$. This gaseous hydrocarbon is obtained by distilling 2 parts of sulphuric acid and one of alcohol. It may be collected over water. It is difficult to purify it from all traces of ether, though when pure it is inodorous. Water absorbs one eighth of its volume of olefiant gas, and ether and alcohol twice their volume. Sulphuric ether frequently contains a trace of olefiant gas. It is combustible, and consumes three volumes of oxygen, producing carbonic acid and water.

OPTICAL CENTRE. Every single lens has a certain point called its optical centre; no such point, however, exists in the case of an achromatic lens, or combination of lenses. This should be distinctly understood, because ignorant persons frequently commit the blunder of speaking of the optical centre of a combination of lenses.

Confining our remarks, therefore, to the case of the single lens.

If a ray of light, incident at any degree of obliquity upon a single lens, strikes it at such a spot as that the direction of the refracted ray within the glass, produced if necessary, passes through a certain point in the axis of the lens called the optical centre, the direction of the ray after emergence will be parallel to that at incidence.

This effect is brought about by the following circumstance:—

A ray of light after refraction through a plate proceeds in a direction parallel to that which it had before. Now if the course of the ray within the glass when produced passes through the point called the optical centre, and we draw a tangent to the anterior surface of the lens at the point of incidence of the ray, and another tangent to the posterior surface of the lens at the point of emergence of the ray, we shall find that these two tangents are parallel, so that the lens for that particular ray may be considered as a plate, and the ray does not suffer deviation by being refracted through the lens, but merely displacement.

The position of the optical centre is constant, and independent of the obliquity of the incident ray; so that in any whole pencil, no matter what its obliquity may be, which is incident upon the front surface of a lens, there is, *provided that surface be large enough*, a particular ray, *and only one*, the direction of which after refraction passes through the optical centre.

The optical centre of a single lens is found thus:—

If $r$ be the radius of the front surface of a lens, $s$ the radius of the back surface, and $t$ the thickness of the lens, then the distance of the optical centre, measured along the axis of the lens from the centre of the face of the front surface, is equal to $\frac{r\,t}{s-r}$

The optical centre of a double convex lens is within the glass;—of a plano-convex lens it is at the centre of the face of the back surface;—and of a meniscus lens it is without the glass and behind it. By giving to $r$ and $s$ the proper algebraical sign, and a given magnitude, the position of the optical centre of any single lens may be readily found.

The use of the optical centre will be understood by referring to the figure on page 1. The focus, or circle of least confusion, of the pencil QAB is somewhere in the neighbourhood of $c$. Now the optical centre of the lens being within the glass the ray Q C $c$ passes through it, and may be considered as very approximately a straight line. If then we draw this line, and set off C$c$ equal to the focal length of the lens, we find the point $c$ very approximately, and without going through the laborious investigation of the bent pencil QRF.

If, in this figure, AB were an achromatic lens, the point $c$ would be found *approximately* by considering the lens as single, or homogeneous, and of the same external form.

In the case of a combination of lenses, this mode of proceeding evidently breaks down. A *combination* can neither have an optical centre, nor any point at all analogous to it.

OPTICAL GLASS. In making flint glass for optical purposes the great point to be attended to is, to prevent the lead from distributing itself unequally, and thus forming *striæ* or waves, from the lead naturally gravitating to the bottom of the pot. Various plans have been adopted which need not be described in this place. The most celebrated optical glass is that manufactured by M. Guinand, of Brennets, near Geneva. His process is a secret. The analysis of Guinand's dense flint optical glass, S. G. 3·616, yields oxide of lead 43·05 per cent., silica 44·3 per cent., and potass 11·75. The best German optical glass is made with 7 parts pure red lead, 3 parts finely ground quartz, and 2 parts calcined borax.

**Organic Matter.** The effects of organic matter in the various photographic processes are described in the article on the chemistry of photography, and also in the particular accounts of these processes.

The general effect of organic matter in combination with the reduced silver of the photographic image is to increase the density of the image when viewed by transmitted light, to redden the colour, to add surface vigour to positive prints, to diminish the chances of permanence of the photograph, and to reduce the sensitiveness of the excited plate or paper to light.

**Orpiment.** $As. S_3$. Yellow sulphide of arsenic. Ammoniacal solution of orpiment is sometimes used as a dye. Orpiment is the basis of the pigment called "King's Yellow"

**Orthographic Projection.** This is a mode of representing an object in perspective, when the eye is supposed to be at an infinite distance, so that the visual rays from the different points of the object are parallel instead of converging to a point at a finite distance, as in common perspective. *See* "Perspective."

**Orthoscopic Lens.** *See* "Lens."

**Oxalate of Iron.** The peroxalate of iron is an important salt in photography, as its solution affords the means of measuring the intensity of actinic power, by observing how much of it is decomposed in a given time, the effect of light being to reduce the salt to a protoxalate, which is deposited, (with the evolution of carbonic acid,) in quantities which are found to be proportional to the intensity of the light and the time of its action.

Peroxalate of iron is made by decomposing the perchloride of iron with oxalate of potass. It is thrown down as a difficultly soluble yellow powder, which is taken up by excess of oxalic acid.

**Oxalate of Potass.** $K\,O,\ C_2\,O_3 + H\,O$. This salt is formed by accurately saturating a solution of carbonate of potass by oxalic acid. It is soluble in rather less than 3 parts of water at 60° ; and is slightly deliquescent.

**Oxalate of Silver.** Ag. O, $C_2 O_3$. Oxalic acid is sometimes formed by the decomposition of collodion, and in this way oxalate of silver is produced in the nitrate bath. It is a white powder, insoluble in water but soluble in nitric acid; it blackens by exposure to light; and forms a double salt with oxalate of potassa.

**Oxalic Acid.** $C_2 O_3 + H O$. This poisonous acid is found in the different varieties of sorrel, in combination with lime or potass. It is readily obtained by acting on sugar with nitric acid. The crystals are intensely sour, and so much resemble those of Epsom salts that persons have been poisoned by mistaking the former for the latter. They are soluble in 15 parts of water at 50°, in 9 at 60°, and fuse in their own water of crystallization at 212° ; in alcohol they are less soluble than in water, and in ether still less than in alcohol.

Oxalic acid, boiled with chloride of gold, throws down metallic gold, and carbonic acid passes off.

The affinity of oxalic acid for bases is about equal to that of sulphuric acid.

**Oxygen.** O=8. (Greek *οξυς* sharp, *γεννειν* to produce.) An elementary gas, the name of which is derived from its property of producing acids. The atmosphere contains about one-fifth part, by *volume*, of oxygen gas, in a state of mixture; and water eight-ninths, by *weight*, in combination with hydrogen.

Oxygen is the great supporter of life and combustion. Animals, by breathing, withdraw it from the air and return carbonic acid in exchange. Vegetables, *during the action of light* in the day time, absorb carbonic acid and return oxygen; hence the balance is maintained.

Oxygen is rather heavier than air, and when pure is tasteless, colourless, and inodorous. Its chief use to the photographer is for affording a brilliant light for exhibiting photographic magic lantern slides, or when a powerfully actinic artificial light is required in any of his operations. (*See* the following article.) The readiest mode of obtaining oxygen for this purpose is as follows:—

A copper retort, containing a mixture of about 3 parts of chlorate of potass and 1 part of black oxide of manganese, (thoroughly well mixed together,) is placed upon a common fire. In a short time oxygen gas is evolved. This is conveyed by an india-rubber tube attached to the nozzle of the retort into a bottle of water, called the purifier, which may stand upon the ground. After passing through the water, which cools and purifies it, the gas passes along another india-rubber tube into a large wedge shaped india-rubber bag, which is capable of containing sufficient gas for an evening's entertainment. This bag may be filled in about half an hour, from half a pound, or less, of the mixed manganese and chlorate. When required for use the gas bag, filled with oxygen, is placed upon the ground 'between two boards hinged together, and upon the upper one weights are laid sufficient to force the gas out at the required rate, along a tube, either to the spirit lamp of the oxycalcium light apparatus, or to the point where it unites with the hydrogen jet of the Bude light,

Perfectly pure oxygen is obtained from chlorate of potass alone, and collected over mercury after having been passed through a tube containing fused chloride of calcium.

OXYCALCIUM LIGHT. This brilliant white light is produced by passing a jet of oxygen into the flame of a spirit lamp, and directing the flame upon a small ball or cylinder of lime. (*See* Fig. 6, page 63.)

OXYMEL. A syrup made by mixing honey and vinegar in the proportions of 1 part by weight of distilled vinegar to 2 parts by weight of purified honey. Evaporate the mixture at 170°, to the consistence of syrup, and strain. Keep it in a cool place. It should be clear, and of a yellowish brown colour.

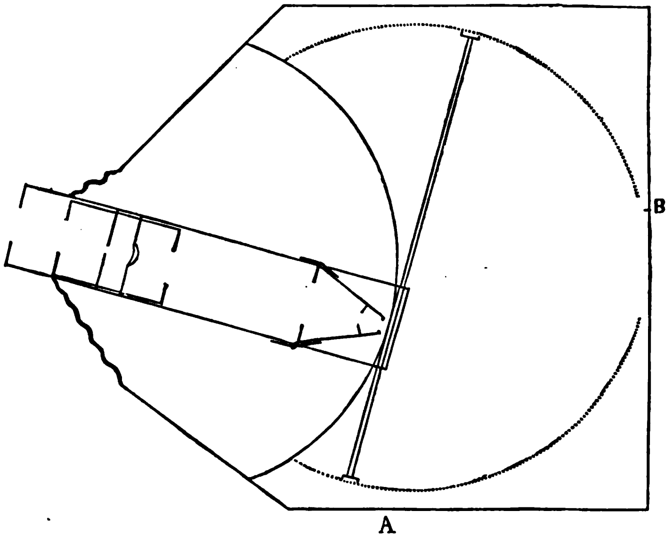
OXYMEL-PROCESS. *See* "Preservative Processes."

OZONE. Supposed to be an allotropic form of oxygen, or oxygen in a peculiarly active state. Some chemists suppose it to be a peroxide of hydrogen, which seems more probable.

"Ozone is formed when electricity is discharged into the air, when water is decomposed, and when phosphorus is allowed to act on moist air at ordinary temperatures. It is best prepared by putting a short stick of phosphorus, well scraped, into a two-quart bottle, with as much water at the bottom as will half cover the phosphorus. The mouth of the bottle should then be slightly closed and the bottle set aside. A column of thin smoke will almost instantly begin to arise from the phosphorus, which is luminous in the dark. Ozone may almost immediately be detected if a piece of paper steeped with iodide of potassium and starch be put into the bottle, the starch becoming blue. When air much charged with ozone is inspired, it becomes highly poisonous. Small animals put into it die; and it acts as a powerful irritant to the air passages. As ozone, a colourless gas, is chiefly recognized by this property, it has led to some curious speculations. By many, its presence, in excess or diminution, is supposed to be capable of explaining many conditions of the air which produce disease. Its smell is precisely similar to what is produced when a powerful electro-pneumatic machine has been long worked, and it is said that the operators in such cases experience symptoms not dissimilar to those of influenza."—*Glover's Chemistry.*

**Panoramic Camera.** This is a form of Camera invented by the author, in which pictures may be taken upon one flat plate, including an angle of 90°, or more if required, without introducing the defects due to oblique pencils, such as distortion, indistinctness, &c.

The following figure will, it is hoped, be intelligible with a few words of explanation.



The lens is mounted in a long narrow tube, or box, the same height as the camera. This revolves about an axis placed immediately over the stop. Inside the camera are placed two hoops, very strong and stout, one at the top, the other at the bottom of it. The dark slide always presses against these hoops. They are circular arcs, the centres of which are in the axis of rotation of the tube. The ends of the dark slide are furnished with wheels, which, as the slide is moved round, travel in grooves at the bottom of the camera, shown by the dotted lines. These dotted curves are evolutes of the lower circular hoop. The top of the lens tube is continued till it passes over the top of the upper hoop, and the bottom of the lens tube is continued till it passes under the bottom of the lower hoop, the dark slide is then placed between these projecting ends of the lens tube. A piece of wood lined with velvet is screwed to these ends, and, by pressing against the back of the dark slide, keeps it in its place against the hoops.

It is evident now, that as the lens-tube is turned about its axis, and directed in succession towards the different objects within the field of view, the dark slide moves with it, and is always pressed against the hoops, thus bringing the proper part of the sensitive plate opposite to the lens,—the velvet-lined piece of wood sliding at the same time against the back of the slide, and the wheels travelling along the evolutes.

The sides of the lens-tube are furnished with folding doors, so as to diminish, at pleasure, the width of the vertical band of picture exposed at any moment; and its rotatory motion may be regulated by means of a rack and pinion on the top of the camera. The shutter of the dark slide may be withdrawn, and inserted again, either through a slit in the camera at A, or B. The mode of doing this may be left to the ingenuity of the reader.

The accuracy with which this novel instrument will do its work will depend upon the accuracy of its construction. The optical principles involve no difficulty, and the theory of the instrument is quite correct. All parts of the picture will be equally sharp, and vertical lines will not be bent out of the perpendicular. The perspective of the picture will, however, be "panoramic," and not "plane," so that the horizontal lines of objects will vanish in curved and not in straight lines. If this be thought an objection, the picture may either be mounted upon a bent cardboard, or bent round a glass cylinder, and viewed in a diaphanoscope, with the eye in the centre of the cylinder. Waxed paper prints, viewed in this way, would probably be finer than anything that has yet been seen in photography.

The panoramic camera will no doubt be found a valuable instrument for taking skies.

PAPER-MAKING. Paper may be made of any *fibrous* material which can be torn and beaten into pulp. The substances commonly employed are linen and cotton rags, and for coarser kinds of paper, grass and straw. We cannot in this work go at any length into the process of paper-making, but will briefly describe the mode of making hand-made paper, from which the general principles of the manufacture will be understood.

The rags are mostly imported from Germany and the different ports of the Mediterranean. They are sorted by women; torn up into shreds, and cut into pieces, then dusted in a machine, and washed, first in water, then in a strong alkaline ley, and afterwards in water again; they are then ready to be made into pulp. To effect this, they are placed with water in a machine called the "engine," where by the rapid rotation of a complicated piece of apparatus, they are torn into the finest imaginable tatters and shreds. This is called "stuff." When the stuff is about half made, it is called "half stuff," and is then "bleached," generally with chlorine, or chloride of lime, one or two pounds of chloride of lime being sufficient for a cwt. of fine rags. This is added to the "half stuff" in the engine, and the mixture is beaten together for an hour or so, then the bleaching liquid run off, fresh water continually added, and the half stuff reduced by the continued action of the engine to "fine stuff."

Sometimes the sizing mixture and colouring matter are now added, but in general the sizing is an after operation performed upon the finished sheets of paper in its bibulous state. The stuff is now run off into the "stuff chest" or vat.

Hand-made paper is made as follows:—

Two men, one called the "vat-man," the other the "coucher," stand on opposite sides of the vat, which is covered with a board or "bridge" between them. The vat is about five feet square, and four feet deep, with slanting sides, and made of wood or stone. The stuff is then diluted with warm water, and continually stirred. The vat-man takes in his hands a mould, which is the size of the sheet of paper to be made. This mould is a frame of wood, having wooden bars running across, about an inch and a half apart, and across them is laid a wire frame, the wires being from fifteen to twenty per inch; or sometimes a *wove* mould is used, covered with fine wire cloth. On the mould a "deckel," or moveable edge frame, is used to prevent the edges of the paper from being rough.

The vat-man puts the deckel upon the mould, and dips it in a vertical position to about half its depth in the stuff, then turns it into a horizontal postion so as to cover it with the stuff, and gives it a peculiar kind of shake, which distributes the stuff evenly upon the mould. The mould must be held perfectly level during this operation, or the sheet will be thicker at one end than the other. The mould is then pushed across the bridge to the "coucher," who, after draining off the water, lays the surface of the pulp upon a piece of felt, to which it adheres, and then returns the mould to the vat-man. This piece of felt, with what we may now call the sheet of paper adhering to it, is laid with other similar pieces in a pile, which, therefore, consists of alternate layers of paper and felt. The pile, consisting of six or eight quires, is put, and remains for some time, under a pressure of about 100 tons, to squeeze out all the water, and the sheets of paper are then removed, pressed again without the felts, and hung across a hair line to dry, in the drying-room.

In this state the paper is bibulous, or blotting-paper, and the next operation is to size it.

English papers are in general sized with a mixture of gelatine and alum, to which sometimes flour, resin, and yellow soap are added. French papers are sized with a less soluble size, consisting for the most part of starch, with a little potass.*

The sheets of bibulous paper are placed, one at a time, in a vertical position in the tub of size, and pressed into close contact. After a time the papers are taken out, scraped, and pressed to remove the superfluous size, then parted, and pressed again, and afterwards hung up to dry, a process which occupies two or three days, and must not be done too quickly. The paper is then pressed again.

The paper has now to be glazed or hot-pressed. This is done by

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* With respect to the sizing of French papers. The following recipe was given some years ago by the Societé d'Encouragement of Paris:—

100 kilogrammes of dry paper stuff,
12 „ starch,
1 „ resin, previously dissolved in 500 kilogrammes of carbonate of soda.
18 pails of water.

This size evidently renders the paper alkaline.

The following formula is given by M. Braconnot, in the "Annales de Chimie," Vol. 23:—

"To 100 parts of dry stuff, properly diffused through water, add a boiling uniform solution of 8 parts flour, with as much caustic potass as will render the liquid clear. Add to it 1 part of white soap previously dissolved in hot water. At the same time, heat half a part of resin with the requisite quantity of weak potass lye for dissolving the resin, mix both solutions together, and pour into them 1 part of alum dissolved in a little water.

This size also renders the paper alkaline. Alum has an acid reaction, and therefore English paper sized with alum and gelatine is acid and not alkaline.

placing a sheet of paper between two glazed pasteboards, alternately in a pile, and between every fifty pasteboards a hot iron plate, then subjecting the pile to the press. Or a pile of sheets of paper placed between pasteboards, may be rolled backwards and forwards upon a plate between cold iron cylinders. This communicates a glaze to the surface of the paper.

The paper is now finished, and has merely to be trimmed, and the sheets counted and sorted, and tied up in reams each containing 480 sheets.

The above operations of making paper by hand may be successfully imitated by machinery; the paper is then said to be "machine-made." It may be made in sheets of indefinite length.

Paper frequently contains metallic spots, consisting of particles of iron, brass, or zinc, detached from the machinery, or introduced through carelessness in sorting the rags. The roughness of the felts between which the paper is pressed also occasions inequalities of texture. It is highly desirable to remove these imperfections from paper which is to be used in photography. The practice employed by the French paper-makers of colouring their paper with artificial ultramarine, (sulphide of sodium,) is also highly objectionable for photographic purposes, both as regards the appearance of the paper, and from the probability that the introduction of an alkaline sulphide into it might assist the process of fading of positive proofs.

Should the process of printing positives in carbon ever come into general use, (which it is tolerably certain that it will,) the imperfections now existing in paper for positives will be of less moment.

**Paper, India or China.** India-paper, or Chinese paper, is much used by engravers for printing the first proofs upon, from the plate. It is thin and silky, of a beautiful buff colour, and made of the fibres of the young bamboo, which are triturated, ground, and boiled to a paste. This is set to ferment in a heap covered with mats, and the paper is then made from it. The length of the fibres renders it better adapted for receiving copperplate proofs than the best European paper. This paper is smooth on one side and bears on the other the marks of a brush which is used in the finishing process. It is made in sheets 4 ft. long and 2 ft. broad. When proofs are printed upon India-paper no cement is used to attach the thin sheet of India-paper to the thick plate paper, the mere pressure exerted by the cylinders in the operation of drawing the proof being sufficient to cause perfect adhesion between the two surfaces.

**PARCHMENT PAPER.** *See* "Artificial parchment."

**PASTE.** Mix well together flour and a little cold water; then add as much more cold water as is necessary to make the paste of the consistence required; then boil the mixture, stirring it well all the time; lastly, strain it through muslin. Starch is better than paste for mounting photographs. Sometimes powdered resin is boiled with paste to give it body, and corrosive sublimate added to make it keep. In the latter case it is highly poisonous, and should not be left about carelessly.

**PENDULUM.** A pendulum suspended in the portrait room may be used with advantage for measuring time by seconds. The pendulum which beats seconds, that is, which oscillates in a second of time (approximately), whatever be the angle of oscillation, is exactly a metre in length, in these latitudes. A metre is nearly 40 inches. If, then, a 40 inch pendulum, hanging against the wall of the portrait room be set swinging before removing the cap from the lens, the operator, by counting its vibrations, may regulate the time of exposure as accurately as if he consulted a watch. A clock having a pendulum a metre in length would be a useful addition to the portrait room.

**PERSPECTIVE.** There are two kinds of perspective delineation with which the photographer is concerned, viz., "Plane," and "Panoramic Perspective."

In plane perspective, objects are represented upon a vertical plane placed between them and the spectator. Straight lines, called "visual rays," are supposed to be drawn from the various angular points A, B, C, &c., of the objects, to the eye, and where these lines perforate the vertical plane, or "plane of the picture," as it is called, are corresponding points *a*, *b*, *c*, &c., through which, if the figure be completed, it is the plane perspective representation of the objects as seen from the point occupied by the eye (not *eyes*) of the spectator. According to this definition a plane perspective view is nothing more than a plane section of the system of pyramids of which the visual rays are the edges and the eye the common vertex; the eye being considered a mathematical point. The rules of perspective, therefore, merely relate to the cutting of pyramids by a plane, and are purely geometrical, not referring in any way to the structure of the eye, or the image formed upon the retina, or the rules of optics. Perspective is nothing more than a very simple problem in solid geometry, and it is marvellous to find that so little is accurately known of it by artists, and that so many elaborate and expensive works should have been written about it, when in fact the whole thing lies in a nut-shell, as we shall now show; not however without calling on the reader for his patient attention, and careful study of our remarks.

Let us first suppose the object to be represented to be an infinite straight line, making an angle, $\phi$, with the plane of the picture, and meeting it in the point A. Then, in order to draw the perspective view of this line upon the plane of the picture, it is evident that we should require to join the point A with some other point X. The question becomes how to find this point X. If it were possible to draw a visual ray from the eye to the end of an infinite straight line, the point where that visual ray would cut the plane of the picture would be the point X required. But is it possible to draw such a line? It is. We have simply to draw through the eye a line *parallel* to the given infinite straight line, and the point X where this line cuts the plane of the picture is found at once; for although parallel straight lines do not meet at any finite distance, they may be considered as meeting at an infinite distance, infinite being only another term for "not finite," and the second form of the expression being identical with the first. But this is becoming metaphysical. Practically, the problem is solved. The finite line AX is the perspective view of the infinite line proceeding from A, and making an angle $\phi$ with the plane of the picture.

Next, suppose any number of other infinite straight lines to make the same angle $\phi$ with the plane of the picture, and to meet it in points B, C, D, &c. It is evident that the perspective views of all these straight lines would be terminated in a common point X, and would consist of lines AX, BX, CX, &c. radiating from X; this point is therefore called the "vanishing point" of that particular system of parallel straight lines.

Hence we arrive at the following general rule:—

*The vanishing point of any system of parallel straight lines is the point where a line drawn through the eye parallel to that system cuts the plane of the picture.*

If a horizontal plane be drawn through the eye the line in which it intersects the plane of the picture is called the "horizontal line;" and if a line be drawn from the eye perpendicular to the horizontal line, the point in which it cuts it is called the "point of sight."

Hence it follows that

1st. The vanishing point of a system of parallel horizontal lines is upon the "horizontal line" of the picture; the point being found by drawing through the eye a line parallel to any one of the system of lines.

2nd. The vanishing point of a system of parallel horizontal lines at right angles to the plane of the picture is the "point of sight."

Now we come to the case of the vanishing point of a system of parallel lines which are parallel to the plane of the picture; that is, to the case in which the angle $\phi$ vanishes. These lines have *no* vanishing point, because the line drawn through the eye parallel to them never meets the picture. They are consequently represented by parallel lines in the picture.

Observe the practical conclusions :—

1st. All vertical straight lines in nature are represented by vertical straight lines in the picture. They do not vanish towards a point in the zenith, as is generally erroneously supposed. In fact, in strict accuracy, vertical lines would vanish downwards towards the centre of gravity of the earth.

2nd. The horizontal lines of a building which are parallel to the plane of the picture are horizontal lines in the picture.

Should the reasoning by which these conclusions are established be thought somewhat metaphysical, then we may return to the case of the section of a pyramid. Place a square board vertically behind the plane of the picture, and parallel to it. Then, since the section of a pyramid by a plane parallel to its base is a figure similar to the base, the perspective view of the square is also a square, that is, neither the vertical nor the horizontal lines have any vanishing point.

We have now discussed the whole theory and mystery of plane perspective. If the reader has carefully followed our reasoning he will not require to spend his money in treatises on perspective, (which are generally full of gross blunders,) but may trust to his own good sense to apply the rules which we have established.

The following remarks should be borne in mind :—

In views of marine scenery, the horizontal line is always higher than the sea line, because of the dip of the visible horizon; and the sea-line is a curve convex to the horizontal line, and most nearly touching it in the point of sight.

The perspective view of a sphere is an ellipse in every case, except that in which the line joining the eye and the centre of the sphere is perpendicular to the plane of the picture, so that the centre of the sphere is on the point of sight. For let a visual ray travel round a sphere, it sweeps out a *cone* with a circular base, and the *oblique* section of such a cone is an *ellipse*.

If the plane of the picture be inclined to the vertical, vertical lines have a vanishing point either above or below the horizontal line.

The reflections of vertical objects in water are vertical, and have no vanishing point, because the image of a vertical line is in the vertical produced *beneath* the surface of the water, and not in a horizontal line lying *upon* the surface of the water, as it appears to be. When the reflection of a vertical line is not represented as a continuation of that line, but as making an angle with it, the perspective is incorrect, no matter in what part of the picture the vertical line may be, or how situated with respect to the point of sight. The reflection of an object which is out of the perpendicular is not necessarily in the same straight line with it, but in general makes an angle with with it.

The reflection of the sun or moon is always vertically under it, no matter where the point of sight may be. Also, the bar of light produced by the reflection of the sun or moon in rippling water is always vertical, and does not appear to approach the spectator, as it is incorrectly represented to do in many pictures. It is always a good plan, therefore, to take the point of sight immediately beneath the sun or moon, when they occur in a picture.

Some of the above remarks may be received with surprise and incredulity by some readers, but a little consideration will shew that they are strictly correct.

*Panoramic Perspective* is when the picture is represented upon a vertical cylinder, of which the eye is in the centre. In this kind of perspective the rules are somewhat more complicated, and need not be stated in this work; it will be sufficient to observe that, in a panoramic picture flattened out, straight lines vanish in curves, not in straight lines.

When the image is formed upon the focussing screen of a camera having a small pin-hole in front instead of a lens, it is in perfectly true perspective; for if we consider the pin-hole as the vertex of the system of pyramids formed by lines drawn from it to the objects, and that these lines are produced *through* the hole so as to form another system, equal and similar to the former, but inverted, it is evident that the section of this second system made by the focussing screen is equal and similar to a section made by a screen placed symmetrically with it on the opposite side of the pin-hole, and therefore equal and similar to a perspective view obtained in the ordinary way, but inverted.

Phosgene Gas. Chlorocarbonic acid. This gas is made by exposing a mixture of carbonic oxide (C O) and chlorine gases, in equal volumes, to the action of sunshine. They combine quietly and form phosgene gas, the volume being reduced to one half. The gas is an acid, pungent, suffocating compound, which is decomposed by water. *See* "Chemistry of Photography."

Phosphate of Soda. There are three phosphates of soda. The common phosphate is obtained by saturating phosphoric acid with carbonate of soda. It is a salt having an alkaline reaction, efflorescent, and soluble in 4 parts of cold water. It has been used in the first preparation of paper in a printing process with phosphate of silver, discovered by Mr. Maxwell Lyte, and which does not require the use of "hypo" for fixing. *See* the following article.

Phosphate of Silver. 3 Ag. O, $cPO_5$. This salt is obtained by adding a solution of common phosphate of soda to one of nitrate of silver. A yellow precipitate falls, which is phosphate of silver. It is fusible at a red heat, and soluble in nitric, phosphoric, and acetic acid, also in ammonia and carbonate of ammonia. It is discoloured by exposure to light. The principle of the phosphate of silver printing process is founded on the solubility of the unreduced phosphate of silver in nitric acid. Unfortunately, the prints are red and require toning, besides being liable to contain chloride of silver and become discoloured in the lights.

Phosphori. Bodies which emit light in the dark, after having been exposed to light, are called "solar phosphori." When we consider that bodies which have been exposed to heat continue to radiate heat for some time after being removed from the source of heat, and that heat and light are most probably undulations in the same ether, differing only in the length of the wave, the existence of solar phosphori cannot be considered a remarkable phenomenon; on the contrary, the wonder is that so few bodies should exhibit the property possessed by them.

The first solar phosphorus on record was discovered about the year 1630 by Cascariolo, a shoemaker of Bologna, who found that calcined sulphate of baryta was luminous in the dark after having been exposed to sunshine, and that it continued luminous for some hours. The matter speedily assumed importance, and considerable quantities of calcined Bolognian spar (the native sulphate employed) were sold as an article of curiosity.

"Canton's phosphorus" is another example of the property. It is made by first calcining oyster shells in the open fire for half an hour; then selecting the largest and whitest pieces, mixing them with about one-third their weight of flowers of sulphur, pressing the whole into a crucible with a closely luted cover, and keeping it at a red heat for an hour. The contents when cold may be turned out and the best pieces selected. They will be found to shine in the dark after having been exposed to sunshine.

Nitrate of lime fused at a dull red heat is also a solar phosphorus.

The blue and violet rays appear to be most effective in producing the phosphorescence. It is not found that solar phosphori generally emit light of the same colour as that to which they have been exposed. There are phosphori from heat as well as from light. The native phosphate of lime found near Estremadura, in Spain, and also some varieties of fluor spar, particularly one called "chlorophane" are the most remarkable instances. These become luminous when slightly heated, or by friction.

Some animal substances are spontaneously phosphorescent. The flesh of the tench, carp, herring, and sole is luminous before putrefaction commences. The property is rarely possessed by the flesh of quadrupeds, and has never been observed in that of birds. The phosphorescence of the sea is a beautiful phenomenon frequently observed, but one which has not yet been accounted for. It is probably due to the presence of phosphorescent animal matter.

The glow-worm and fire-fly are familiar instances of phosphorescence possessed by living animals.

Decayed wood and certain mosses have been known to exhibit phosphorescence, but the property is rare in the vegetable kingdom.

Some salts, (sulphate of potass for instance,) emit light during crystallization.

PHOSPHORUS. P=32. This remarkable elementary body is contained in the bones and fluids of animals, and also in the vegetable and mineral kingdoms. In bones it exists as phosphate of lime, and is obtained from them by acting on calcined bones with sulphuric acid, and distilling the superphosphate of lime thus produced with the addition of charcoal. The phosphorus, which is volatile, passes over, and its vapour is condensed and drops into water. It is at first a soft translucent yellowish white substance, but becomes red by exposure to light, which is supposed to afford an instance of allotropy. It is insoluble in water, but soluble in oils and in ether.

Phosphorus is highly combustible and burns slowly and spontaneously in the air, but magnificently in oxygen. It should be kept, and cut, under water. Its chief use is for making lucifer matches.

PHOTO-GALVANOGRAPHY. This is a process for producing copper plates ready for the printer by the joint action of light and electricity. A company was formed at Holloway, in 1856, for carrying out the process, under a patent obtained by Herr Pretsch, who superintended operations.

We paid a visit to the establishment in November of that year, and Herr Pretsch was kind enough to explain the various stages of the process. We subsequently wrote the following article in "Photographic Notes." No. 15, describing what we had seen and heard.

"A positive photographic print is first taken,—generally on paper. In order to produce from this a copperplate the following operations are employed:—

"First;—A sheet of glass is coated with gelatine containing bichromate of potass, and other chemicals. When dry, the positive is laid upon it, face upwards, and it is exposed to light in a pressure frame for a few hours. The time of exposure of course depends on the intensity of the light. Sunshine is preferred, but is not necessary. The picture upon the gelatine is developed in raised and sunk parts by immersion in a fluid, the principal constituent of which is water. Where the light has *not* acted, the gelatine swells and forms a ridge, or a series of minute granulations. Where the light *has* acted, the gelatine is hardened and does not swell. The picture upon the gelatine is very curious, and resembles a positive by reflected light, the shadows and dark parts being rough and the lights smooth and polished.

"Second;—A mould of the picture upon the gelatine is taken in gutta percha. This mould is an intaglio picture, precisely resembling the finished copper plate. The gutta percha mould is about half an inch thick.

"Third;—A copper plate is made from the gutta percha mould, by means of the electrotype process. This part of the process is very slow, occupying perhaps a week or two. The copper plate thus obtained is called the matrix. It precisely resembles the original gelatine picture.

"Fourth;—The copper plate from which the proof is to be printed is now obtained by the electrotype process from the matrix. This is a slower process than the last, because the copper is much thicker. It occupies about three or four weeks.

"The entire process therefore occupies about six weeks. From the final plate four or five hundred good impressions may be struck in the ordinary way;—a considerable number of plates may be obtained from the matrix;—a considerable number of matrices may be taken from the gutta percha mould;—and a considerable number of gutta percha moulds from the gelatine picture. Here then are the means of almost indefinite multiplication. Some idea of the number of proofs which might be obtained from the original gelatine picture would perhaps be got by multiplying 500 by itself four times. This gives more than sixty thousand million impressions; that is, sufficient proofs for six times the present population of the earth. The most elaborate subjects may be engraved by this process in as short a time as the simplest, the amount of detail in a photograph or photo-galvanograph making no difference, for light, chemistry, and electricity do the work. The time at present required for any subject is a few weeks; the time frequently spent on engravings is two or three years."

The company ceased operations a few months ago, probably from the process not being in a sufficiently perfect state to render them independent of the help of the engraver for retouching their plates. This is much to be regretted, because the process is perfectly suitable for a class of bold artistic subjects which, taken from nature by photography and multiplied in printers' ink, would be of great service as studies for artists, or copies for drawing masters to lay before their pupils.

PHOTO-LITHOGRAPHY. This process, like the last, is in a somewhat imperfect state, but it will no doubt receive further development and become eventually of much practical utility. It consists in producing from a negative a positive upon stone which will take printers' ink, and may be printed from in the same way as an ordinary lithograph. Two methods have been employed which are totally different in principle, since one depends upon the oxidizing, the other the deoxidizing power of light. The first method was described by Mr. Macpherson at a meeting of the Photographic Society of Scotland on Dec. 9th 1856, and was reported in "Photographic Notes," No. 18, as follows:—

"Take a piece of bitumen of Judea, about 1½ inch square; pound it in a mortar till it is reduced to a very fine powder; then put it into a stopped bottle. Pour upon this, 6 ounces of pure sulphuric ether. Shake it for ten minutes, and then let it stand for five minutes till the powdered bitumen has fallen to the bottom, leaving the ether perfectly transparent, but of a rich brown colour. This liquid is useless, and must be poured off into a bottle, which it is desirable should be kept for such liquids as may afterwards be redistilled, and once more become pure and serviceable ether. To return to the original bottle, containing the sediment of bitumen:—6 ounces of pure ether must be again poured upon this bitumen. Shake the bottle well for a quarter of an hour, and then pour the contents of it through a paper filter into a clean stopped bottle. This liquid is now in a state for use, and the sediment remaining may be thrown away, as it can never again be used. I may mention that the liquid should be of a beautiful brown transparent colour. Take a lithographic stone, (the blue ones are better than the yellow—the difference between the blue and yellow tints being about the same as in blue and yellow post paper);—see that the printer has prepared it with a very fine grain, as if for a chalk drawing. Place it upon a table, in a room with ordinary day-light,—but avoiding the sun's direct rays. Let it be levelled with a spirit-level, till it is perfectly horizontal. There should be no current of air in the room, and the operator should move as little as possible, either before or after the operation, that any movement of his body may not cause a current. His breath should also be held for a few seconds. He is then ready to begin, and for that purpose should pour out as much of the liquid into a wine glass, as will be required to cover the surface of the stone —a quantity which experience alone can teach him. He then pours it gently and slowly, but regularly, on to the centre of the stone. It immediately runs all over, and spreads itself; and he must be again cautioned against withdrawing his arm quickly so as to produce a current of air. In less than a minute the whole of the ether will have evaporated, leaving a dry looking light brown surface, which, on examination by a powerful lens, ought to appear granular, in other words ought to be composed of myriads of fine dots or stipples.

"The negative, if of glass, must then be laid down upon the stone; and great attention is required in laying it down, so that it may be at once put upon that part of the stone which is desired, for it must not afterwards be shifted, or the surface will be destroyed. It is then desirable to surround the negative with slips of pasted paper, so as to paste, and so attach, the negative closely to the stone, and in that way prevent air or dust getting between the stone and negative. It may then be exposed to the light. The exposure will be regulated by the experience of the operator. In my own experience it varies from half an hour to three days; but I think the three days' exposure, without the sun, more likely to be successful than the half hour's exposure with the sun. The stone must then be removed into the operating room, the pasted slips of paper run round with a penknife, and the negative at once lifted cleanly off the stone. The operator can then more leisurely remove the slips of paper with a knife or other sharp instrument. A zinc bath is then placed horizontally on the table; into the bath is poured as much ether as will give a depth of $\frac{1}{8}$ of an inch. The stone must then be let into the bath, face downwards, exactly as one silvers an albumenized plate—that is gently, but without hesitation or jerk. After it has been there for 8 or 10 seconds, it ought to be raised to an angle of 45° two or three times, up and down. Great dexterity is now required. The stone must be at one movement turned over face upwards, and the upper end of it made to rest upon the side of the bath, which ought not to be more than 3 inches high. At this part of the operation an assistant is required, who should be ready with a few ounces of pure ether, which he at once pours over the stone, with a continual movement back and forward, along the upper end of the stone. This ether runs rapidly down, washing away any loose particles of bitumen, which had not been perfectly removed by the washing in the bath. You then place the stone upon a table leaning against a wall, and you see before you the image upon the stone. Should the shadows instead of being dark appear light, and the lights appear dark, the operator will know that it is good for nothing, and that over-exposure was the cause of failure.

"The stone should now be placed in the hands of the printer, who will etch it, as he would a chalk drawing, using perhaps a little less acid; he will then cover it with gum in the usual way, and the next day it will be ready for printing. A great deal depends, as in lithography generally, on its being put into the hands of an experienced picture lithographer. The stone admits of no re-touching, but letters can be added with the use of lithographic ink, as required. I may add that the impressions always look best on India paper, on account of the tint.

"I have never worn out a stone. Of each of the two specimens exhibited 500 copies have been thrown off and no difference could be seen between the first and the last."

The second process was patented in England by M. Poitevin, of Paris, on April 15th, 1856. The specification of the patent gives the following particulars:—

"I print photographically, with ink of a greasy nature, upon paper, lithographic stone, metal, glass, wood, or other suitable material, in the following manner:—

"I apply upon the surface which is to receive the design one or more layers or films of a mixture of equal parts of a concentrated solution of albumen, fibrine, gum arabic, gelatine, or similar organic substance, and a concentrated solution of a chromate or bichromate of potass, or of any base which does not precipitate the organic matter of the first solution. This single or compound layer or film is then dried, if the photographic impression is to be produced by contact; or it may be used in a moist state when the photographic impression is to be produced in the camera obscura. In producing the impression by contact, the surface is covered with a photographic negative picture, or an engraving, or other transparent or partially transparent object or screen, and then exposed to light as in the ordinary photographic process. After a sufficient exposure, if the surface has become dry, or has been used in a dry state, it is moistened with water by means of a sponge, and while moist the greasy ink or matter is applied to the surface by a ball or dabber, or by a roller or press, or otherwise, and it will be found to adhere to those parts only which have been affected by the light. Thus, if the screen employed be a negative, having the lights and shades reversed, the print will be a positive, with the lights and darks correct; and if the screen be a positive, the print will be a negative. The print may be retained on the surface upon which it is first produced, or it may be transferred or printed upon paper, or other suitable material, and the operation repeated. I thus obtain a design upon lithographic stone, or other suitable material, from which I am enabled to multiply impressions by the method of lithographic printing by inking the moistened surface with a greasy ink."

Mr. Macpherson is not the *inventor* of the bitumen process; M. Nicéphore Niépce first used bitumen in photography, and M. Negre, of Paris, first applied it to photo-lithography.

**PIGMENTS.** Positive prints may now be obtained in various pigments, by mixing them with an organic substance, and bichromate of potass,—applying the mixture evenly to the entire surface of a sheet of paper, drying it, and exposing it under a negative,—then washing it in water or a suitable solvent, which removes the pigment from those parts of the paper which have *not* been acted on by light, and leaves it firmly cemented to the paper in the parts which *have* been so acted on. The process of printing in pigments has not yet received much attention and the results are at present more or less imperfect as compared with those by the old processes; but since prints by the methods in common use are extremely liable, if not certain, to fade, it is of the utmost importance that the methods of printing in carbon and permanent pigments should be so far improved as to yield results artistically equal to the others.

The following is a brief account of some of the common pigments:—

*Black.* Ivory black is made by calcining ivory dust in a close crucible. Lamp black is the soot produced by the combustion of oils, resins, and other vegetable substances.

*Umber.* A brown mineral found in the island of Cyprus; it is composed of silica, alumina, and oxide of iron and manganese. When calcined for half an hour at a red heat the pigment called burnt umber is produced.

*Asphaltum.* A fine rich brown pigment. *See* "Asphaltum."

*Sienna.* An argillaceous mineral found in Italy, and also near Wycomb. By calcination it becomes burnt sienna.

*Smalt blue.* A glass coloured with oxide of cobalt, and pulverized.

*Cobalt.* Hydrate of alumina mixed with hydrated oxide of cobalt, dried and calcined.

*Sulphate of Indigo. Chemic blue, Saxony blue.* Indigo dissolved in about six times its weight of sulphuric acid, then diluted with water, and neutralized with potass.

*Prussian blue.* A compound of cyanogen and iron. It is not considered a permanent pigment.

*Stone blue.* Finely powdered indigo mixed with starch paste, and made into lumps.

*Copper blue.* A mixture of carbonate of copper and chalk, exposed to the air until it assumes the proper colour.

*Ultramarine.* A pigment composed chiefly of a costly mineral called *Lupis lazuli,* brought from China and Persia.

*Artificial ultramarine.* A pigment containing sulphide of sodium, obtained by fusing together in a crucible, porcelain clay, sulphur, and carbonate of soda. French photographic papers are tinted with this villanous alkaline sulphide, which is enough of itself to cause the fading of any photograph.

*Blue verditer.* Nitrate of copper mixed with chalk.

*Copper green.* Native sub-carbonate of copper.

*Brunswick green.* Carbonate of copper mixed with calcareous matters.

*Vienna green.* A mixture of arsenious acid and verdigris.

*Green verditer.* An accidental variety of blue verditer.

*Sap green.* The juice of the berries of buckthorn, black alder, or ever-green privet, mixed with lime water and gum arabic, and evaporated until quite thick.

*Iris green.* The juice of the petals of the iris added to quick lime.

*Carmine.* An extract from the cochineal insect.

*Lake.* The colouring matter of raw shellac.

*Brazil-wood lake.* A mixture of a decoction of logwood, alum, and chloride of tin, to which carbonate of soda is added to form a precipitate.

*Madder.* A colouring matter obtained from the root of the *Rubia tinctorum*, which grows in the South of Europe.

*Brown pink.* To a decoction of French berries and fustic, boiled with potass in a *tinned* vessel, alum is added. The precipitate is "brown pink."

*Dutch pink.* Turmeric is substituted for fustic, and whiting for alum, in the preceding formula.

*Orange red. Sandix.* White lead calcined.

*Red lead. Minium.* Litharge (oxide of lead), roasted in a reverberatory furnace.

*Indian red.* Peroxide of iron.

*Red chalk.* Clay iron-ore.

*Venetian red.* Oxide of iron.

*Alum white.* A calcined mixture of honey and alum.

*White lead.* Basic carbonate of lead.

*Permanent white.* Carbonate of baryta.

*Zinc white.* Oxide of zinc.

*Chrome yellow.* Chromate of lead.

*Indian yellow.* A concretion formed in the intestines of the camel.

*King's yellow.* Sulphide of arsenic.

*Naples yellow.* A calcined mixture of lead, antimony, alum, and salt.

*Patent yellow.* Chloride of lead.

*Queen's yellow.* Turpith mineral, or sub-sulphate of mercury.

*Yellow lake.* French berries boiled with potass, and precipitated with alum.

*Ochres.* Native oxides of iron mixed with argillaceous and calcareous earths.

*Verdigris.* Acetate of copper.

*Indigo.* A product obtained from the indigo plant.

*Sepia.* The black liquid contained in the cuttle fish. It consists of carbon, along with albumen, gelatine, and phosphate of lime.

*Vermilion. Cinnabar.* Protosulphide of mercury.

*Terra verte.* Silicate and phosphate of protoxide of iron.

PINS. Pins are used in photography for hanging up papers by the corners to dry, or for pinning the corners to a board. Black pins coated with enamel are the best.

PIPE CLAY. A clay analogous to kaolin and found in the Isle of

Purbec, and Dorsetshire. It contains a large proportion of Alumina, and is sometimes used for decolorizing old nitrate baths.

Plaster of Paris, Gypsum. This useful substance is made by roasting sulphate of lime at a temperature of about 500°, by which the water of crystallization is expelled. When plaster of paris is made into a paste with water, it soon solidifies, and this property constitutes its value for taking casts or moulds. Stucco and scagliola are made by mixing plaster of paris, coloured in various ways, with size and water, and polishing the surface. Gypsum, or native sulphate of lime, is frequently used as a manure, particularly for clover crops. Sulphate of lime is soluble in 500 parts of water and it is this salt which principally renders water "hard."

Plate. In optics, a transparent medium bounded by parallel plane surfaces is called a "Plate." When a ray of light is refracted through a plate, its direction at emergence is parallel to that at incidence, and it does not suffer deviation but only displacement; the amount of displacement depending on the thickness of the plate. The same thing happens when a ray is refracted through any number of plates of different materials in contact;—it merely suffers displacement and not deviation;—the medium external to the plates being supposed to be the same.

Plate Glass. This is made of the same materials as crown glass, and does not contain lead. Vast quantities of it are now used in photography. Plate glass is made by pouring a quantity of the fused "metal" upon a table or cuvette of cast iron, and then passing a roller over the surface. The plate is then annealed or allowed to cool slowly in an oven, or carquaise, along with others. When cold the plate is removed, and carried in an upright position to a part of the manufactory where it is to be roughened down and polished. This is accomplished by fixing one side of the plate with plaster of paris to a horizontal stone table, and another plate to a piece of apparatus above it. The apparatus is then put in motion, and the surface of the upper plate rubbed upon that of the under one, with wet sand between them, by a circum-rotatory motion, at the same time that a peculiar lateral motion is given to the table which supports the lower plate. When the plates are in this way sufficiently worked on one face, the process is repeated on the other. The plates are next smoothed in the same way by substituting moist emery for moist sand, and the polishing is effected by colcothar (oxide of iron) applied by rubbers of felt. The final polishing is given by women, who rub two plates together with a little moistened putty of tin between them.

Manufacturers of plate glass should be particular not to pack it up, when intended for photography, with printed papers between the sheets, for it has been found that permanent impressions are thus communicated to the glass, which are reproduced upon the photograph. It has been affirmed that these impressions cannot be removed by the strongest nitric acid.

**Plate Paper.** The thick bibulous paper upon which engravings are printed.

**Plumbago, Blacklead, Graphite.** This substance is composed of carbon and iron, and contains about 8 per cent. of iron. The finer kind is used for blacklead pencils, and the coarser kinds for polishing grates, diminishing friction in machinery, &c. It is almost exclusively obtained in a pure form from the mine of Borrowdale, in Cumberland; it is infusible, very difficult of combustion, and sometimes occurs crystallized in hexangular plates. In an impure form it is not an uncommon mineral, and is found in detached masses, generally among primitive rocks.

**Plumbers' Solder.** Equal parts of lead and tin.

**Polarized Light.** *See* "Light."

**Portrait Room.** The construction of the room in which portraits are taken is a matter of the first importance. The best arrangement for producing a pleasing expression in the countenance of the sitter, an artistic effect of light and shade, and a portrait free from distortion and disagreeable exaggeration of near objects, is as follows:—

The room should be at least 30 feet long, 10 feet wide, and 8 feet high at the sides. The roof should have a ridge from end to end. Both ends of the room should be dark, and nearly in the middle there should be a window on each side coming down to within 3 feet of the floor and going up to the roof. In the roof there should be two skylights exactly corresponding in breadth with the windows, and going up to the ridge. The width of the windows and skylights need not exceed 5 feet. They should be provided both with black and white blinds, which can be drawn at pleasure, and also with the means of opening and shutting them in calm or hot weather. The background is placed at that end of the room which is nearest to the windows and the camera at the other. White screens, moveable on rollers, should also be at hand when required to throw a reflected light upon any part. The room should be entirely papered with a very dark blue paper; and the eyes of the sitter should never be directed towards the light, but into darkness.

The portrait room should, if possible, be built of wood, and made to turn about an axis in the centre, with two wheels at each end, so that it may be placed in any direction with respect to the light. When this is not practicable it should be placed north and south, and the sitter should face the north. A lens of long focus and large aperture should be used in preference to one of short focus and small aperture; not because a large aperture is better than a small one, but because it is at present a matter of unavoidable necessity. A lens of too short focus for the size of the picture produces horrible distortion in the image. Photographers generally are too fond of straining their lenses and working with oblique pencils. The only objection which can properly be raised against a lens of long focus and suitable aperture is that which arises from the room being filled with the smoky atmosphere of a town, which renders the picture indistinct and produces fog when the camera is too far from the sitter. To avoid this evil, portraits should always be taken in the suburbs and not in the centre of a large town.

The floor of the portrait room should be covered with light holland in the neighbourhood of the sitter, and with dark drugget at the end opposite to him. Chairs, sofas, tables, vases, &c., should not be polished, because the high lights look like spots of snow in the picture. Nothing plain, or poverty-stricken, or of ugly design should appear in the portrait room; on the contrary it should be furnished with articles of taste and luxury, but not with anything gaudy or distracting to the eye. The camera stand should be placed upon a platform mounted on wheels.

In taking a portrait, one of the side windows should always have either the white or black blind drawn, and the same may in general be said of one of the skylights. The object of this is to throw more light upon one side of the face than the other.

POSITIVE COLLODION PROCESS. *See* page 120.

POTASS. $KO=47$. Hydrate of Potass, $KO, HO=56$.

"Caustic Potass," or hydrate of potass, is obtained by boiling together in an iron vessel slaked lime and a solution of carbonate of potass. The carbonic acid leaves the potass and goes to the lime, forming an insoluble precipitate of carbonate of lime, and the potass remains in solution. When a little of the liquid taken out ceases to effervesce on the addition of an acid, the decomposition is complete. The clear liquid is then drawn off into an *iron* or *silver* vessel, evaporated to dryness, fused in its own basic water, and run into moulds. The sticks thus formed still contain a little carbonate; this is removed by dissolving them in absolute alcohol, when the carbonate of potass is precipitated as insoluble, but the plan is open to objection since the alcohol is liable to be decomposed.

Caustic potass is soluble in half its weight of cold water. It is highly alkaline and caustic, acting energetically upon most organic substances, and dissolving sulphur, alumina, silica, and several sulphides; its aqueous solution, also, dissolves the oxides of some of the metals, as manganese, zinc, lead, tin, antimony, cobalt, nickel, &c., and acts upon glass, particularly when at a boiling heat. It is freely soluble in alcohol and fuses at a red heat.

POTASSIUM. $K=40$. This singular metal is obtained by expelling the oxygen from potass either by exposing it to intense heat in contact with charcoal, or by Voltaic Electricity. It is a bluish white metal of great lustre, which fuses at 150°, boils at a red heat, floats upon water, and takes fire by coming into contact with water in consequence of its great affinity for oxygen. It must be preserved under naphtha.

PRESERVATIVE PROCESSES. The object of these processes is to preserve the sensitiveness of an excited collodion plate for a longer or shorter time, as may be required, and thereby to do away with the inconvenience of preparing the plate and developing the picture on the spot whence the view is taken.

The best *dry* preservative processes at present known are undoubtedly those of Dr. Hill Norris, and Mr. Fothergill, described under the head of "Dry Collodion Processes;" *q. v.* With respect to the moist preservative processes, various plans have been suggested, (some right and others manifestly wrong in principle,) which consist in removing more or less of the free nitrate of silver from the sensitive plate by washing it and then pouring over it such a substance as glycerine, golden treacle, oxymel, or honey, which retains its moisture for a great length of time. After the exposure, and immediately before the development, the plate is well washed in order to remove the preservative substance, and the picture is then developed, either with gallo-nitrate, or pyrogallo-nitrate of silver, and fixed in the ordinary way.

Of the substances named as preservatives, golden syrup, or glycerine, or a mixture of golden syrup, and metagelatine, are probably the *best*, and oxymel or honey the *worst*. The objection to honey consists in its containing a large quantitiy of grape sugar, which is a powerful reducing agent and tends to fog the plate without increasing its sensitiveness; while golden syrup is entirely *un*crystallizable and a very feeble reducing agent, therefore a much more suitable substance than honey to employ. The reducing action of the grape sugar contained in honey is kept at bay somewhat by adding vinegar to it, and forming oxymel; but when an acid is present in the preservative, not only is the time of exposure greatly increased, but the latent image is gradually destroyed by it between the time of exposing the plate and developing the picture. Some time ago an amusing spectacle was exhibited by two photographers, each contending for the honour of the discovery of the honey process. We believe more honour would have been gained at the time by any one who had then pointed out the *dis*advantages which attend, and the error of principle which is involved in the use of it. Glycerine appears to be inert and well adapted for a preservative agent, particularly when the nitrate of silver is not thoroughly washed off.

In any preservative process it is always well to add a chloride, say chloride of magnesium, to the iodizing solution, and the collodion should not be too hard and contractile.

The deliquescent salts, nitrate of magnesia, and nitrate of zinc, have been tried as preservatives, but they do not appear to answer.

The theory of preservative processes appears to be this:—The sensitiveness of the excited collodion plate is impaired, but not altogether destroyed, by washing off the free nitrate of silver. An image perfect in all its details may be impressed upon a washed collodion plate, by sufficiently increasing the time of exposure; but in the development nitrate of silver must be added to replace that which has been removed. The impressed image cannot be removed by simple washing in water, although it may be dissolved out by immersion in an acid nitrate bath, or by acid oxymel, or acid gelatine or any acid developer, or other chemical agents. The effect of a moist preservative solution poured over the plate is therefore (supposing it to be quite inert), merely to retain the moisture of the film during the time that it is in contact with it.

A good moist preservative process is chiefly valuable to the professional photographer (who must of necessity work collodion in a van or tent near the spot where the picture is taken), for taking interiors, or subjects which require a very long exposure. To the amateur it is useful for enabling him to excite and develop the plate at the inn where he is staying. If an excited plate be required to be "kept" more than a few hours, Dr. Norris's dry process is certainly far better than any moist preservative process. *See* "Collodion."

PRINTING INK. This may be applied as a backing to collodion positives, and it does not crack. To apply it, first rub the back of the plate over with it, then smear a piece of paper with it, press the two blackened surfaces together, and put the plate at once into the passe-partout. It may also be used for blackening the skies of collodion negatives.

Printers' ink is made by grinding lamp-black in printers' varnish, which is a mixture of linseed oil, resin, and yellow soap. By adding more varnish it may be thinned to any extent.

PRINTS, COLOURING. Before colouring an engraving or photograph upon bibulous paper, it must be sized by applying to it the following mixture:—

Dissolve 4 ounces of glue and 4 ounces of white soap in 3 pints of hot water; add 2 ounces of powdered alum; stir well together, and it is ready for use. It is to be applied cold, either with a sponge or flat camel-hair brush.

PRINTING PROCESS. By "printing" is meant the reproducing a positive, in which the lights and shades are true to nature, from a negative in which they are reversed. The operation not being attended with the destruction of or injury to the negative may be repeated indefinitely, and therefore any number of prints may be taken from the same negative.

There are two methods of printing; one consists in copying the negative by means of a lens, the other by pressing it upon a sensitive tablet in a pressure frame, and exposing it to direct light. In both cases the light which produces the print is transmitted through the transparent parts of the negative, and stopped by its opaque parts. The particulars of the former method are described in the article on "Copying," (*q.v.*) It only remains therefore to describe the latter mode of proceeding, viz., printing by superposition.

There are two methods of printing by superposition of the negative upon a sheet of sensitive paper. One is called Sun-printing, the other Development-printing.

In sun-printing the paper is said to be either "plain" or "albumenized." The latter process is minutely described at page 13.

The process of Sun-printing upon Plain paper is as follows:—

Use the best Papier Saxe, or the papers of Marion, or Canson; all of which are manufactured on the continent, and have a finer surface than English papers.

Float the face of the paper for a minute upon a bath composed of—

| | |
|---|---|
| Filtered rain water. . . . . | 1 oz |
| Gelatine . . . . . . . . | 3 grains |
| Chloride of sodium . . . . | 6 grains. |

The ingredients are to be boiled together, strained, and used when cold. Hang the papers up to dry by a pin at one corner.

Excite the paper by brushing over it, with a Buckle's brush, the following solution of ammonio-nitrate of silver.

| | |
|---|---|
| Distilled water. . . . . | 1 oz |
| Nitrate of silver . . . | 50 grains |

When dissolved add ammonia, a drop or two at a time, until the brown turbidity at first formed is exactly redissolved, and the solution becomes again clear.

Brush the papers over *twice* with the above, and hang up to drain.

When as many have been excited as are required for immediate use, dry them before the fire at a moderate distance, and use them at once, for they turn brown by keeping.

Expose in the pressure frame until the picture is somewhat overprinted.

On removing it from the pressure frame, wash it (in the dark room) in several changes of rain water, then with water to which a few drops of ammonia have been added, lastly with water again. It is now of a reddish purple tint.

Tone it by immersion in a very small quantity of a bath containing

| | |
|---|---|
| Distilled water . . . | 6 ounces |
| Sel d'or . . . . . . | 1 grain |
| Hydrochloric acid . . | a few drops. |

From one to five minutes immersion in this bath is sufficient. The tint changes from a reddish purple to an indigo colour, while the whites are but slightly changed. The bath must not be used again.

Wash the print thoroughly in water changed a dozen times at least, then fix it in a bath containing 1 part of hyposulphite of soda to 20 parts of water. Let it remain 20 minutes in this bath, then throw the hypo away, and wash the print in water, and let it soak in water frequently changed and agitated, for 24 hours.

Press between cloths, hang up to dry, and the print is finished.

The simplest Development-printing process is as follows :—

Use Hollingworth's *thin* photographic paper; (the thick sort is useless.) Immerse it in the following bath:—

| | |
|---|---|
| Filtered rain water . . . | 1 ounce |
| Salt . . . . . . . . . | 6 grains |
| Lemon juice . . . . . | 1 drop. |

The time of immersion may lie between one minute and 24 hours without producing any marked difference in the result.

Excite the paper by floating it upon a nitrate bath made thus:—

| | |
|---|---|
| Distilled water . . . . | 1 ounce |
| Nitrate of silver . . . . | 30 grains |
| Lemon juice . . . . . | 6 or 8 drops. |

Hang it up to dry, and use it as soon as possible.

Expose it in the pressure frame until a faint trace of the picture is visible.

Develop it thus:—

Turn up the edges of the paper all round so as to make it into a tray. Lay it, with a sheet of blotting paper underneath, upon a horizontal sheet of glass, and pour upon the darkest part of the picture a little saturated solution of gallic acid, which spread with a bent glass rod. The development immediately commences and is completed in a few minutes. Do not stop it at too early a stage, before the blacks have acquired the proper intensity.

Wash the picture once or twice in rain water, and fix it exactly in the manner described in the preceding process.

When finished it should precisely resemble an engraving in appearance.

By adding a little iodide of potassium to the salt, the paper is rendered much more sensitive and the print more permanent, its colour is also improved by an admixture of grey or blue; but the process is less manageable and certain.

These processes have been somewhat briefly described because the Author has learnt, within a few days, the particulars of a method of printing in carbon, which he feels sure must speedily supersede all the processes with the silver salts, from its economy and certainty, as well the undoubted permanence of the prints. This process, however, (the discovery of Mr. John Pouncy, of Dorchester,) he is not at liberty at present to make public.

**Prism.** In solid geometry a prism is a solid described by the motion of a straight line which in passing round the boundary of a plane rectilineal figure always preserves its parallelism, the solid being terminated at the other extremity by a plain figure parallel to the first. In optics, however, the term prism is confined to the case of a prism with a triangular base, and its sides rectangles perpendicular to the base.

In optical experiments with the prism the edge of the prism is in general very sharp, the two adjacent planes which form it being inclined at a very small angle, called the "refracting angle of the prism." When the prism is so placed with respect to a ray of light refracted through it as that the emergent and incident rays make equal angles with the sides of the prism, the deviation of the refracted ray is a minimum.

Suppose a prism to be placed in its position of minimum deviation with respect to a ray refracted through it near its edge, and let D be the deviation of the refracted ray, $\mu$ the index of refraction of the material of which the prism is made, and $a$ the refracting angle of the prism; then, *if the angle made by the incident ray be small*, $D=(\mu-1)\,a$.

A ray of light refracted through a prism is decomposed into rays of different refrangibility and colour, because the deviation of a ray depends upon the refractive index of the prism for that ray, and since white light is not homogeneous but composed of light of different degrees of refrangibility, the refractive index will vary with the different rays of which white light is composed, being greatest for the violet and least for the red rays, therefore the deviation will be different for rays of different colours.

If a second prism, precisely similar to the first, be placed against it in such a way as that its edge is next to the base of the first prism, the two prisms will form a plate, and a ray refracted through them will neither suffer deviation nor decomposition; that is to say the effects produced upon it by refraction through the first prism will be exactly counteracted by refraction through the second, so that the second prism will re-compose into white light the rays which were dispersed by the first. The second prism therefore achromatizes the first; *but the refracted ray does not suffer deviation*, there is therefore no optical utility in such an arrangement. But if the second prism be made of a different material from the first, having different refractive and dispersive powers, and a suitable refracting angle be given to it, the first prism will be achromatized by the second, *and the ray will suffer deviation.* This important result depends on the fact that the dispersive power of a medium is not proportional to the deviation produced by it.

This being the case, opticians are fortunately able to achromatize lenses and prisms. To be very exact however, it must be remembered that in consequence of the irrationality of dispersion 2 prisms in contact can only unite 2 of the coloured rays or lines of the spectrum.

PROOF-SPIRIT. Alcohol, S. G. ·92 at 62° Fahrenheit. *See* "Alcohol."

PRUSSIAN BLUE. A peculiar compound of cyanogen and iron, the exact formula of which has not been determined, but may be represented approximately by $6\,KO + 4\,Fe._4\,Cfy._3$.

This substance is much used both as a dye, and pigment. It is made by precipitating solutions of peroxide of iron with ferro-cyanide of potassium, (yellow prussiate of potass.) It is insipid, inodorous, insoluble both in water and alcohol, and not poisonous. The alkalies decompose it, and it does not therefore, as a dye, resist the action of soap. According to Chevreul, it becomes white by exposure to sunshine, but recovers its colour in the dark. It has a strong attraction for water.

PRUSSIATE OF POTASS, RED AND YELLOW. *See* "Ferro-, and Ferrid-Cyanide of Potassium."

PUMICE STONE. A grey porous stone found in the neighbourhood of active and extinct volcanoes, and supposed to have been thrown up by them. It is used by painters for smoothing surfaces intended to be painted; and, when pounded, by other artificers for polishing glass, metals, &c.

PURPLE OF CASSIUS. This is a fine purple pigment used in enamel painting, and staining glass of a red colour. It is composed of the mixed oxides of gold and tin, and is precipitated by immersing a piece of tinfoil in a solution of chloride of gold. Its composition is $Au.O + 3Sn.O_2 + 4HO$.

PUTTY. *See* "Glazier's putty."

PUTTY POWDER. POLISHER'S PUTTY. Peroxide of tin.

PYRO-ACETIC ETHER; PYRO-ACETIC SPIRIT. $C_3\,H_3\,O$. This is a colourless, limpid, inflammable liquid, sometimes called "Acetone." It is permanent in the air, and mixes in all proportions with water, alcohol, ether, and turpentine. It is obtained by the destructive distillation of acetate of copper, or other acetates. It appears to be of no present use in photography, although like many other substances it has been tried by experimentalists, as an addition to collodion.

PYRO-GALLIC ACID. $C_6 H_4 O_4$. This substance is extensively used by photographers as a developer in the negative collodion process.

It may be made by exposing gallic acid to a temperature of about 420°, when it sublimes and may be collected in the form of white shining scales; but is apt to be contaminated with empyreumatic oil.

A better plan is to treat finely powdered galls with successive portions of cold water until exhausted, then to collect all the infusions and evaporate them to dryness. The spongy deliquescent mass thus produced must then be pounded and spread upon the bottom of an iron vessel 3 or 4 inches deep and 1 foot in diameter, the top of it being covered with a piece of blotting paper pierced with pin holes, and surmounted by a paper cap 12 or 18 inches high. The pan is then cautiously and uniformly heated for some hours at a temperature of about 400°. The crystals of pyrogallic acid collect in the cap, and the other products are absorbed by the blotting paper.

Pyrogallic acid is not an acid, and does not redden litmus paper. It is white, crystalline, inodorous, and bitter; and very soluble in water, alcohol, and ether. The aqueous solution blackens by long exposure to air, and deposits a brown powder. It gives a deep *indigo* colour to a solution of *proto*sulphate of iron, if *pure* and free from *per*sulphate, to which it gives an *orange* colour.

Pyrogallic acid is blackened by chlorine, but iodine has no effect upon it.

It is a powerful deoxidizer, and reduces the oxides of the noble metals; hence its use as a developer in photography. It combines with oxide of lead, and forms a white powder.

PYRO-LIGNEOUS ACID. A crude vinegar obtained by the destructive distillation of wood. When purified it is used as a substitute for vinegar in many processes of the arts, and also in making pickles, sauces, &c.

PYRO-LIGNEOUS SPIRIT. PYROXYLIC SPIRIT. *See* "Wood-Alcohol."

PYROXYLINE. $C_{24} H_{15} N_5 O_{40}$. This substance, which when dissolved in ether forms collodion, is made by acting on lignin with a diluted mixture of sulphuric and nitric acids represented by the formula $HO, NO_5 + 2 HO, SO_3 + 3\frac{1}{2} HO$, the temperature being uniformly maintained at from 135° to 150°, according to the quality of the collodion required.

It may either be made from cotton wool, or linen rags. The rags must first be boiled in a strong solution of soda, and then thoroughly washed. The mode of proceeding will be understood from the following description, extracted from a treatise by the author on the "Positive Collodion Process."

"Procure some dry cotton wool chemically clean, some pure sulphuric acid, S. G. 1·84, some pure nitric acid, S. G. 1·5, and some rectified sulphuric ether, S. G. ·750.

"Use the fire-place of an outbuilding for the experiments. Put an old frying pan filled with sand upon the fire, and in this sand-bath place a pie-dish containing water heated to about 170° Faht. Then procure a breakfast cup and a couple of long thick glass rods.

"1st Experiment.—Put into the cup

5 drachms Nitric Acid, by measure.
5 drachms Sulphuric Acid ,,
25 grains Cotton Wool.

"Dense suffocating fumes rise from the mixture; these should escape up the chimney. Keep working the cotton wool about with the glass rods for 5 minutes, during which time the temperature of the mixture should be 150°. The temperature of the water in which the cup stands being about 170°, that of the mixture in the cup will be as nearly as possible 150°; but you must test it with a thermometer, the ball of which can be inserted in the mixture; for the preservation of an even temperature is of the utmost importance.

"At the end of five minutes, remove the cup, throw away the mixed acids, and put the cotton into a pail of water. Wash it quickly, opening it well, and rousing it about in the water. Then continue the washing in a basin, changing the water several times, and squeezing the cotton after each washing between your hands.

"When you have thoroughly washed and squeezed out all traces of the acids in this way, pull the cotton out into a large loose ball, and hang it up to dry gradually in a clean piece of netting. The cotton when dry looks pretty much as it did at first, but you feel a peculiar harshness about it.

"The first experiment yields pyroxyline of the most explosive kind. Be careful therefore of accidents.

"Repeat the experiment ten or twelve times, adding in the second experiment 30 minims of water to the acids, and increasing the quantity of water added by 30 minims in each fresh experiment. The twelfth experiment will therefore contain, in addition to the acids, 330 minims, *i. e.* 5½ drachms of water.

"We will now suppose the various samples of gun-cotton to be dry, and ready for an investigation of their properties.

" First—weigh them.

| | | | | |
|---|---|---|---|---|
| Sample | 1 | will weigh | 43 | grains |
| „ | 2 | „ | 43 | „ |
| „ | 3 | „ | 43 | „ |
| „ | 4 | „ | 42 | „ |
| „ | 5 | „ | 37 | „ |
| Samples | 6, 7, 8 | | 37 | „ |

" The cotton having increased in weight from 75 to 50 per cent., according to the quantity of water added.

" We now proceed to test the solubility of these twelve samples of gun-cotton in ether, S. G. ·750, and also to ascertain the various properties of the film produced when the solution is poured upon a glass plate. Observe that ether, at ·750, contains a proportion of alcohol and water; the S. G. of absolute ether, being only ·720.

" Weigh two grains of each sample of gun-cotton, and test their respective solubility in half an ounce of ether.

" Samples 1, 2, and 3, will be found to be insoluble. Sample 4 looks more gelatinous, and seems inclined to dissolve. Sample 5 dissolves completely on shaking the bottle. Samples 6, 7, 8, 9, 10, are soluble; 11 partly so; 12 not at all.

" Now compare the different samples of cotton. The first three or four are long and fibrous, the next three or four are somewhat shorter, the last three or four become very short, and break up into little short shreds, many of which are lost in the washing.

" The first three or four samples are called " Pyroxyline," and the last three or four " Xyloidine." But it will be seen that this nomenclature is imperfect, for it does not include the middle varieties, which are those with which we are concerned in Photography, viz: Nos. 5, 6, 7 and 8. We will call them photographic gun-cotton.

" The first samples of pyroxyline are highly explosive. Place a small tuft upon the hearth, and apply to it the end of a red-hot piece of iron wire. It instantly goes off 'puff,' without smoke, and leaving no ash. The last varieties of xyloidine are merely combustible, and not explosive.

" Let us next examine the nature of the solutions made with samples between Nos. 5 and 10.

" Pour a few drops of No. 5 upon the finger, so that it may run round both ways. It dries quickly (producing a sensation of cold), and, when dry, contracts strongly, looking like a piece of goldbeater's skin, stuck tightly round the finger. This is the hard contractile collodion. Its use should be avoided in photography.

" Now pour a few drops of No. 10 upon the finger. This also dries quickly, but when dry does not contract like the former, and instead of being transparent, is semi-opaque, or "opalescent," or "papyraceous," looking like a piece of tissue paper stuck round the finger. This is also a kind of collodion to be avoided in photography.

"The proper variety of gun-cotton for photographic purposes lies between these extremes.

"In order to try which is the best, pour a little of each solution upon a clean glass plate. But in order to make the experiment fairly, wait a day or two, until the floating particles in the collodion have settled to the bottom of the bottle; for you cannot properly filter collodion without a special apparatus.

"Examine the films before a strong light, with the help of a magnifier.

"Film No. 5 is not only hard and contractile, but shows structure, being covered with wavy marks, or lines.

"Films Nos. 6 and 7 are much better and are nearly structureless; No. 6 is the best.

"Film No. 8 begins to get slightly opaque.

"In films Nos. 9 and 10 the opacity increases.

"No. 6 is therefore the best collodion, and on adding a little alcohol to it, the appearance of structure in the film altogether vanishes. It adheres tightly to the glass, without contracting, and cannot easily be washed off."

The proper strength of the nitrosulphuric acid, determined from the above experiments, does not agree exactly with the formula given in symbols in a former paragraph, and which is that of Mr. Hadow; but some latitude is allowable in that formula, and the best proportions are purely a matter of experiment.

Before putting the cotton into the acids it should be pulled out into very thin flat pieces.

Instead of using mixed acids, a mixture of sulphuric acid and nitre may be employed. The ingredients must be pure, and the nitre finely pulverized and dried.

Mix together—

| | |
|---|---|
| Water . . | . 1½ fluid drachms. |
| Sulphuric acid . | . 12 ,, ,, |

And pour it upon

| | |
|---|---|
| Pure nitre . . | . 600 grains. |

Stir it well until it ceases to effervesce, and forms an even pasty mixture free from lumps. This mixture must be kept at a temperature not lower than 135°, and used at once, as it solidifies on cooling. The cotton must be kneeded in the mixture for about 10 minutes. This plan of making pyroxyline is not nearly so good as with the mixed acids.

In using commercial acids of unknown strength, the exact quantity of water to be added is a matter easily determined by two or three experiments.

The theory of pyroxyline is as follows:—Lignin is composed of carbon, oxygen, and hydrogen. When acted on by nitrosulphuric acid, from 3 to 5 equivalents of hydrogen are removed, and their place supplied by peroxide of nitrogen, by a process called in chemistry "substitution." The only effect of the sulphuric acid appears to be, to prevent the nitric acid from dissolving the pyroxyline; for sulphuric acid has a strong attraction for water, and pyroxyline is soluble in *dilute* though not in *strong* nitric acid. The theory expressed in symbols is $CH_n O + NO_5 = C (H_{n-1}, NO_4) O + HO$. Lignin + nitric acid = pyroxyline + water, in which expression the *number* of atoms involved in the change is, for the sake of simplicity, omitted.

Pyroxyline being a substitution compound is very unstable. Bottles containing it are frequently filled with red fumes, and by its decomposition in the form of a collodion film, oxides of nitrogen are given off which destroy the picture. It should, therefore, be dissolved in ether as soon as made, and collodion pictures should always be varnished.

Pyroxyline is sometimes made from Swedish filtering paper; but the plan is liable to the objection that paper may contain mixed fibres of different kinds, which would be unequally acted on by the acids, at the same time that the fibres in the interior of the paper are not so readily acted on as those at the surface. These constitute weighty objections to the use of filtering paper.

For further information on this subject *see* "Collodion."

QUICK LIME. Oxide of calcium, free from carbonic acid and water. It has a powerful affinity for water, and when "slaked" by the addition of water is converted into "hydrate of lime." The heat evolved is so great as to reach 500°, and when the operation is conducted in the dark *light* is also evolved. One part of lime is soluble in 150 parts of water, and the solution is called lime-water. Quick lime is used in several metallurgic processes as a cheap and powerful flux; and in many chemical operations as a means of depriving other substances of their water. It is highly alkaline and caustic.

QUICKNESS OF LENSES. The comparative "quickness of lenses," (as it is termed,) depends *partly* on the colour of the glass, the number of glasses in the combination, the number of reflecting surfaces, &c.; but *mainly* on the aperture of the lens, and its focal length.

It is evident that, other things being equal, the intensity of light in the image depends first on the quantity of light admitted, and secondly on the area over which it is distributed. It varies, therefore, *directly* as the aperture, and *inversely* as the size of the picture.

But the size of the picture given by a lens varies directly as the square of its equivalent focal length; and the area of the aperture, or diaphragm, varies as the square of its diameter. Therefore the time of exposure varies *directly* as the square of the equivalent focal length, and *inversely* as the square of the diameter of the aperture or stop.

In the same lens the time of exposure varies inversely as the square of the diaphragm used. For instance, with a diaphragm of half an inch diameter the time of exposure must be *four* times as great as with a diaphragm of one inch.

The equivalent focal lengths of two different lenses may be compared by directing them towards the same objects from the same spot, and comparing the distance between the same objects in each picture. In this method, however, allowance is not made for distortion.

**RAMSDEN'S EYE-PIECE.** This telescopic eye-piece is used as a focussing magnifier to magnify the image formed on the focussing screen of the camera. It is composed of two plano-convex lenses, equal in all respects, and mounted in a tube with their plain sides outwards, at a distance apart equal to two-thirds of the focal length of either. When using this magnifier, the image on the ground-glass should be nearly in its principal focus. It is used in telescopes when spider-lines are placed in the focus of the object glass. It is sometimes called the Positive Eye-piece, and is not achromatic.

**REALGAR.** $As.S_2$. Red sulphide of arsenic. This substance is used in making "White Indian Fire," (*q. v.*) It is easily fused, and sublimed.

**REAUMUR'S THERMOMETER.** In this scale 0° is taken as the freezing point, and 80° as the boiling point of water. *See* "Thermometer."

**RECOVERY OF WASTE SILVER.** A great deal of silver is wasted by photographers. Most of it might be saved by a little care and management. Washings containing nitrate of silver should be collected in a pan and common salt added, which throws down insoluble white chloride of silver. When this has settled to the bottom, the clear liquid should be drawn off by a syphon, and the chloride collected and put into a bottle. Old nitrate baths may be treated in the same way. When a tolerable quantity of chloride has been collected in this way it may be sent to the refiner, who will give nitrate of silver in exchange for it. Messrs. Johnson, of Hatton Garden, are purchasers of chloride of silver. Old hypo-baths frequently contain a large quantity of silver, both in solution as a double hyposulphite of silver and soda, and as a black precipitate of sulphide of silver. In order to obtain the silver, sulphuric acid should be added to the bath; this throws it down as a brown or black sulphide of silver, which may be sent to the refiner, who will give nitrate of silver in exchange for it.

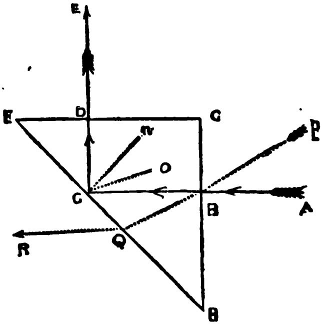
The best mode of reducing either the chloride or sulphide of silver, is to dry it, and mix it in a crucible with about twice its weight of carbonate of soda, (common washing soda,) then place it in 'the hottest part of the kitchen fire, and urge the fire with the bellows until the silver melts and forms a button of pure silver at the bottom of the crucible. No other mode of reduction is so simple and trustworthy. But before having recourse to this process, the chloride or sulphide should be well washed in many waters.

**Red Heat.** 980° Fahrenheit, according to Daniell. The heat of a common fire is about 1150°.

**Red Lead.** $Pb._3 O_4$. This fine pigment is made by exposing litharge to the action of air at a temperature of about 560°, by which it absorbs oxygen and becomes converted into red lead. The brilliancy of the colour is reduced by exposure to light.

**Reflecting Prism.** Suppose FGH to be a glass prism having equal sides FG, GH, and the angle at G a right angle; and let AB be a ray of light incident at B perpendicularly to the side GH. This ray will not suffer deviation on entering the glass, but will proceed in the same straight line till it comes to C. What will then happen to it?

Draw C*n* at right angles to FH, and make the angle *n*C*o* equal to the "critical angle" of the glass. (*See* "Refraction.") This angle will lie between 39°, and 42°, according to the refractive index of the glass, being the least for flint and the greatest for crown glass. Therefore all rays within the glass incident at C and not lying within the angle *n*C*o* will suffer total internal reflexion. Now the angle *n*CB=45°, and is therefore greater than *n*C*o*, consequently the ray BC is internally reflected at C, and follows the rectilinear course CDE, CE being at right angles to CA.



It appears therefore that the back of a glass prism may be used as a reflector.

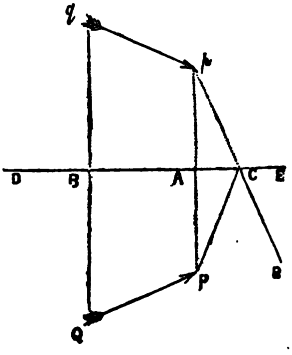
With respect to *oblique* rays incident at B. It is evident that all rays incident at B and lying within the angle ABH will suffer internal reflexion, but between A and G there will be a limit, for a ray PB whose direction BQ within the glass makes an angle BQH greater than *o*CH, will *not* suffer total internal reflexion, but will pass through the prism in the direction QR. In order for this to happen, the angle PBA must be greater than about 9° when the prism is made of dense flint glass. All rays therefore lying within a space PH, nearly equal to 100°, suffer internal reflexion; and those lying within PG pass through the prism.

**Reflexion.** When a ray of light is incident on a polished surface of any kind, it is turned out of its course, and suffers "reflexion."

The law is, that the reflected ray lies in the same plane with the incident ray and the normal to the reflecting surface at the point of incidence; and that it makes with the normal an angle equal to that made by the incident ray, on the opposite side of it, but on the same side of the reflecting surface.

In all cases of reflexion a part only of the light is reflected, the remainder being scattered or absorbed.

**Reflexion at a Plane Surface.** When a virtual image of a luminous object is formed by reflexion at a plane surface, there is no spherical aberration in the pencils, nor any distortion in the image, and the image is situated in exactly the same relative position with respect to the reflector, *behind* it, as the luminous object in *front* of it. As these points should be clearly understood we shall demonstrate them with the help of a diagram.



Let PQ be a luminous object placed before a plane reflector ED; and let PC be any one of the rays of the pencil proceeding from P. This ray after reflexion at C will follow a course CR such that CR and PC make equal angles with CD. Draw the line PA perpendicular to the plane of the reflector, and produce it to *p*, making A*p* =AP. Join *p*C. Then in the triangles PAC, *p*AC, which lie in the same plane, *p*A=PA, CA is common to both, and the included angles at A are right angles, therefore the angle *p*CA=PCA. But the angle ECR=

PCA, and is in the same plane with it; therefore $p$C A=ECR; CR is consequently in the same straight line with C$p$. Hence it follows that the reflected ray CR, if produced backwards, passes through $p$. But the position of the point $p$ does not depend upon the distance AC, or the angle PCA; it is therefore the same for every reflected ray of the pencil from P. Therefore $p$ is the virtual image of P, and the reflected pencil is entirely free from aberration.

In the same way it may be shewn that if Q be any other point of the object, and Q$q$ be drawn perpendicular to the reflector, BQ being equal to B$q$, $q$ is the virtual image of Q.

Hence it follows that $pq$ the virtual image, and PQ the object, are symmetrically situated with respect to the plane of the reflector DE, on opposite sides of it.

REFRACTION. When a ray of light passes out of one transparent medium into another of different density it is bent out of its course, and suffers deviation.

The law is, that the refracted ray lies in the same plane with the incident ray and the normal to the surface at the point of incidence; and that it lies on the opposite side of the normal, and makes with the normal an angle of refraction the sine of which bears to the sine of the angle of incidence a constant ratio, depending on the nature of the two media.

When refraction takes place from vacuum into a medium, this constant ratio is called the "refractive index" of the medium, and is generally denoted by the Greek letter $\mu$. It is always greater than unity.

If then, $\phi$ be the angle of incidence
$\phi'$ " refraction
the law of refraction is expressed by the equation

$$\text{sine } \phi = \mu \text{ sine } \phi'$$

which is called the "Law of Sines."

The sine of an angle is a decimal fraction less than unity, and may be found by consulting a table of natural sines. The sine of 0° = 0; of 90° = 1; of 30° = ·5; and so on. *See* "Sine."

Suppose then the refractive index of a piece of glass to be 1·54, and the angle of incidence of a ray upon its surface to be 37° 18′; required to find the angle of refraction.

By consulting the table we find that the sine of 37°18′ = ·60599 :—

$$\text{Therefore } \cdot 60599 = 1{\cdot}54 \times \text{sine } \phi'$$

which gives sine $\phi' = \cdot 3935$

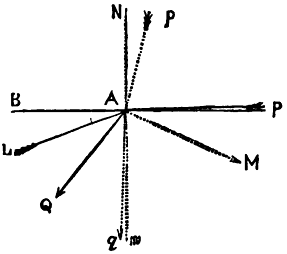
Consulting the table again, we find that ·39341 is the natural sine of 23°10′, and ·39367 the natural sine of 23°11′; therefore the angle of refraction, $\phi'$ is equal to 23°10′ 20″.

The following table gives the value of $\mu$ for a few different substances.

| | |
|---|---|
| Chromate of lead | 2.974 |
| Diamond. | 2·439 |
| Nitrate of silver. | 1·788 |
| Flint glass | from 1·625 to 1·58 |
| Crown glass | from 1·542 to 1·514 |
| Canada balsam | 1·55 |
| Castor oil | 1·49 |
| Turpentine | 1·475 |
| Nitric acid | 1·41 |
| Alcohol | 1·372 |
| Acetic acid | 1·36 |
| Ether | 1·358 |
| Water | 1·335 |
| Air | 1·000276 |

We have now to consider the case of a ray about to pass from a dense medium into vacuum.

A ray of light on having its direction reversed returns by the same path as that by which it came; so that if PNB be a vacuum, P*n*B a dense medium, and *p*A*q* the bent course of a ray proceeding in the direction of the arrow, if this ray be reversed and turned back it will follow the course *q*A*p*. If then the angle $pAN = \phi$, and $qAn = \phi'$, the equation sine $\phi = \mu$ sine $\phi'$ becomes sine $\phi' = \frac{1}{\mu}$ sine $\phi$.



If $\phi'$ be such that $\phi = 90°$, sine $\phi'$ will be equal to $\frac{1}{\mu}$; and the angle whose sine is $\frac{1}{\mu}$ is called the "Critical Angle."

Suppose, now, PA to be a ray whose angle of incidence differs from 90° by a quantity less than any assignable quantity; it will then after refraction follow the course AQ, and QA*n* will be the "critical angle." This angle for plate glass is about 42°, and for flint glass about 39°, therefore less than 45° in both cases.

Now observe what follows:—

Any ray within the dense medium, proceeding towards A and lying within the angle $nQ$, will emerge and take a direction somewhere within the angle PN; *but no ray incident at* A *whose direction lies within the angle* QB *will be able to get out of the glass*, but will suffer total reflexion, as shown in the figure by the ray LAM; the angle $LAn$ being equal to the angle $MAn$.

The meaning and importance of the critical angle will now be perceived; for the inner surface of a transparent medium may become a totally reflecting surface; and a block of transparent glass may be as perfectly opaque to light as a sheet of iron. It is on this principle that the reflecting prism is constructed; (*q. v.*).

REFRACTIVE INDEX. See the preceding Article.

Practical opticians generally determine the mean refractive index of their glass by making it into a lens of known surfaces, and finding by trial the focal length of the lens.

A more scientific way is to make it into a prism of small angle, decompose a ray of white light through it, close to the edge, and at the angle of minimum deviation; receive the spectrum upon a telescope, and measure the deviation of a ray corresponding with a certain dark line of the spectrum, by means of a suitable instrument furnished with verniers.

The different coloured rays of the spectrum have different refractive indices, that for violet being the greatest, and for red the least.

RENNET. The stomach of the calf, salted and dried. It is used for curdling milk. *See* "Whey," and "Casein."

RESINS. Resinous substances are an abundant vegetable product, and are frequently obtained by making incisions in the bark of trees. In some cases the resin, which is then called a "balsam," occurs mixed with volatile oil, which either evaporates or becomes oxidized and resinified by the action of air and light. In other cases it occurs mixed with gum, and is then called a gum-resin. Bitumens and fossil resins are supposed to be products of antediluvian vegetables.

Most of the resins are soluble in anhydrous alcohol, and many of them in ether, sulphide of carbon, and the oils.

The alcoholic solutions of some of the resins are acid, of others neutral, and of others alkaline. Ammonia does not precipitate the acid solutions, but forms with them an ammonio-alcoholic solution, which in general precipitates a white powder on the addition of nitrate of silver.

Acetic acid, and also nitric acid, dissolve many of the resins.

Common resin, or Colophony, is the residue of the distillation of turpentine. It contains water at first, and is then yellow. When deprived of this by fusion it becomes black.

Some of the resins are of great use in making varnishes. *See* "Varnish."

**Reverse Action of Light.** Sometimes those parts of a negative which should be the most opaque come out perfectly transparent through over-exposure. This is called the "reverse action of light." It happens most frequently when the bath is acid with free nitric acid. Solarization, in all the processes, may be considered as the first step towards this extreme action of light upon iodide of silver, and if the exposure were sufficiently continued, the complete effect of the reversion of the lights and shades would probably occur in all cases. This reversion may be produced by exposing a plate to diffused light for a second or two after pouring on the developer.

If the latent, or invisible image upon iodide of silver, be produced by actual reduction by light, (which is highly probable,) then it is not difficult to understand how over-exposure may carry the reduction to such a stage as that the reduced material may cease to be a substance for which the decomposing pyrogallo-nitrate has an affinity. If, by the excessive action of light, the developable material in the sensitive film be reduced nearly to the *metallic* state, then it is easy to conceive that it could not be intensified, (for we know how impossible it is to intensify the metallic precipitate of a glass positive); while, from its existing in extremely minute quantity, it might be removed along with the iodide of silver in the fixing process. At any rate this appears to be at present the most plausible way of accounting for the "reverse action of light," as it is improperly called.

**Rice Water.** This is sometimes added to the iodizing solution in the waxed-paper negative process. It is made by boiling whole rice in water for a few minutes and then straining the liquid. The proportions are quite empirical, and the operation of very questionable utility. Serum of milk is a much better organic substance to add to the iodizing solution when it is required to obtain the effects due to organic matter.

**Rock Crystal; Quartz.** This may be considered as pure silica. It occurs in fine large six-sided prismatic crystals, which are extremely hard. The finest specimens come from Madagascar, and the Alps; the Bristol and Cornish diamonds are also good specimens. Rock crystal is used for spectacles, and sometimes for lenses. It has about the same refractive index as glass, and is beautifully transparent, and very cold to the tongue.

**ROTTEN STONE.** A mineral found in Derbyshire. It is reduced to fine powder, and used for polishing metals, daguerreotype plates, &c. When used for the latter purpose, it should be sifted upon the plate through a fine muslin strainer.

**ROUGE; COLCOTHAR; CROCUS.** Red oxide of iron. Used for polishing glass, metals, &c.

It is prepared thus:—

Make a boiling solution of sulphate of iron, filter it, and add to it a concentrated solution of oxalic acid; this throws down yellow oxalate of iron. Wash the precipitate, and heat it, while still moist, upon an iron plate, over a charcoal fire. At a temperature of about 400° the salt is decomposed, and brown-red peroxide of iron, or "rouge" formed in a very finely divided state.

Daguerreotype plates should not be polished with rouge, because the iron clings to the silver and injures the tone of the picture.

**SAL-AMMONIAC.** Chloride of ammonium; *q. v.*

**SALTPETRE.** Nitrate of potass; *q. v.*

**SAL-VOLATILE.** Carbonate of Ammonia, in powder, mixed with ethereal animal oil: 4 parts of the former to 1 part of the latter.

**SANDARACH.** Juniper resin. A resin much used in varnishes, and the produce of the *Thuia articulata* which grows in Barbary. Sandarach usually occurs in small yellow drops, easily fusible, and soluble in alcohol.

**SAPONIFICATION.** Soap is a combination of a fatty acid contained in oil with a strong alkali. The principal acids contained in oils are, the stearic, margaric, and oleic; and when existing in oils they are combined with a peculiar base called "Glycerine," (*q. v.*) or oxide of glyceryle; so that when an oil or fatty substance is boiled with a strong alkali, as soda or potass, the feeble base glycerine is displaced by the more powerful one, and the results are soap and glycerine. This is the theory of saponification.

**SEALING WAX.** The best sealing-wax is made with shellac, or dammar, the inferior sorts with common resin.

The following are the compositions of the best kinds of coloured sealing wax :—

*Red Sealing-wax*—

| | |
|---|---|
| Shellac | 2lbs. |
| Venice turpentine | 1lb. |
| Vermilion, or sub-chromate of lead | ½lb. |

*Black Sealing-wax*—

| | |
|---|---|
| Shellac | 2lbs. |
| Venice turpentine | 1lb. |
| Lamp black | ½lb. |

Melt the shellac and turpentine together with heat, and add the pigment as the mixture cools.

*Common black bottle wax is made thus* :—

| | |
|---|---|
| Black resin | 6lbs. |
| Bees' wax | ½lb. |
| Lamp-black | 1½lb. |

Neither Venetian red nor red-lead should be substituted for lamp-black, because the latter is inert, and not acted on by chemicals.

SEA-WATER. Sea-water has been sometimes used in photography instead of a solution of common salt. The composition of the water of the English Channel, according to the analysis of Schweitzer, is as follows :—

| | |
|---|---|
| Water | 964·74372 |
| Chloride of sodium | 27·05948 |
| ——— potassium | ·76552 |
| ——— magnesium | 3·66658 |
| Bromide of magnesium | ·02929 |
| Sulphate of magnesia | 2·29578 |
| ——— lime | 1·40682 |
| Carbonate of lime<br>——— magnesia | ·03301 |
| | 1000·00000 |

Sea-water contains, therefore, about 16 grains of chlorides to the ounce of water. When used for positive-printing it would therefore, in general, require to be diluted with an equal bulk of fresh-water.

The water of the Mediterranean contains a trifle more saline matter than that of the English Channel.

The clamminess and stickiness of sea-water is due to the presence of the magnesian salts. Its average specific gravity is 1·027 ; and the average of its saline contents 3½ per cent.

SEED LAC. *See* "Lac." Seed-lac is said to be more soluble in alcohol than shellac, and therefore to make clearer varnish.

**Sel d'Or.** $Au. O, S_2 O_2 + 3 [Na. O, S_2 O_2] + 4 H O$.

This salt is a double hyposulphite of gold and soda, containing 4 atoms of water of crystallization. It is made by adding 1 part of perchloride of gold to 3 parts of hyposulphite of soda, each dissolved in 500 parts of water. The liquid is colourless, and contains several salts besides sel d'or. The solution of gold must be added to that of soda, and not the solution of soda to that of gold. In the reaction which takes place, 8 atoms of hyposulphite of soda, 1 atom of chloride of gold, and 4 atoms of water, form 2 atoms of a sulphur salt of soda, 1 atom of sel d'or, and 3 of chloride of sodium. Thus:—

$$8 [Na. O, S_2 O_2] + Au. Cl._3 + 4HO =$$
$$2 [Na. O, S_4 O_5] + 2 \text{ Sel d'or} + 3 Na. Cl.$$

The sel d'or is precipitated from the solution made as described above by the addition of alcohol. It crystallizes in fine needles, which are very soluble in water.

Sel d'or sometimes contains a considerable proportion of common salt and hyposulphite of soda.

Neither hyposulphite of gold, nor hyposulphite of silver can be isolated. They only exist in double salts.

Sel d'or is used for toning positive prints. It acts very energetically if used before the print has been fixed in hypo. The rationale of its action appears to be, that the gold of the sel d'or is substituted for the silver of the print, so that oxide of silver, plus sel d'or, becomes oxide of gold, plus the soluble double hyposulphite of soda and silver. In this method of toning no sulphide of either metal is formed, and it cannot be considered in the light of a sulphur-toning process. When chloride of gold is added to hyposulphite of soda in excess, the sulphur salt $Na. O, S_4 O_5$, which is produced would, if not removed, constitute a sulphur-toning bath. Hence the advantage of using sel-d'or instead of the toning and fixing bath commonly employed, and described in the article "Albumenized-paper Printing Process."

**Sepia.** (Gr. σηπια, a cuttle-fish.) Sepia is a fine, rich, brown pigment, obtained from the black liquid which is ejected by the cuttle-fish, in order to darken the water when pursued. The sac which contains the colour is extracted from the fish, and the juice dried as quickly as possible.

The colouring matter consists of carbon in an extremely divided state, along with albumen, gelatine, and phosphate of lime. The brown colour is obtained by acting on it with a caustic alkali.

Sepia may probably be found a valuable pigment for the [illegible]ting processes in carbon and pigments, in which bichromate of [illegible] is used as a mordant when reduced by light.

Sepometer. (Gr. σηπω to putrefy.) An instrument invented by Mr. Angus Smith for determining, by means of the decoloration and decomposition produced in permanganate of soda, the amount of organic impurity existing in the atmosphere of towns. These organic impurities in the atmosphere no doubt considerably affect photographic operations, and the photographer should not be without the means of testing their presence. The aqueous solution of permanganate of soda is of a purple colour, and is decolorized by agitating it in contact with air containing ammonia, sulphuretted hydrogen, and sulphurous and phosphorous acids. It is also decomposed by organic matter, being a powerful oxidizer.

Serum of Milk. Serum, or whey, is the watery liquid which remains after the cream and cheese have been removed from milk. It contains a sugar called sugar of milk and some soluble salts, also a small quantity of uncoagulated casein. It is of great use in photographic printing upon plain paper for giving surface vigour to the proofs without any disagreeable glazed appearance;—and in the paper negative process it seems to act better than any other substance in giving density to the blacks, probably from the presence of the salts of lactic acid which it contains.

The simplest and best mode of making whey for the paper processes is to add lemon juice to skimmed milk in the proportion of about 2 spoonsful of lemon-juice to a quart of whey. Boil them together and strain the liquid through a cloth, which separates it from the curd. It should be of a greenish colour and slightly opalescent. About 6 grains of salt may then be added for positive printing paper, and about 5 grains of salt and 10 of iodide of potassium for negative paper. The acidity of the whey thus prepared preserves the whites of the paper beautifully.

Whey may be made by adding a piece of rennet about 3 inches square to a quart of skimmed milk, and putting it in a bason on a hob so as to raise the temperature to about 120°. In half an hour or so the curd is formed. This is called sweet whey, from its not being so acid as the other. It contains rather more casein.

Shellac. *See* "Lac."

Silica. Si. $O_2$. Oxide of Silicum. Silicic acid. This is a substance existing abundantly in nature, and occurring in nearly a pure form as flint, and rock crystal. When perfectly pure, and free from water, silica exists as a white insipid powder, insoluble in water and most solvents, and nearly infusible; but when existing in the form of a hydrate its properties are very different; it is then soluble to some extent in water and in acids, and at a high temperature is itself capable of acting as a powerful acid which decomposes even some of the sulphates. By evaporating an aqueous solution of silica gelatinous silica is precipitated; this on being dried becomes again quite insoluble.

Silica, and the silicates, enter largely into the composition of glass.

SILVER. Ag.=108. The Luna, or Diana, of the alchemists.

This valuable metal occurs native and also in a variety of combinations, but principally as sulphide. It is chiefly found among primitive rocks. The richest mines are in Peru and Mexico, and the richest in Europe are those of Saxony, Bohemia, Swabia, and that of Konigsberg in Norway.

Silver at high temperatures resists the action of air for a long time, and does not oxidize; but it is easily tarnished by sulphuretted hydrogen, particularly when it is alloyed with copper. It is sometimes found crystallized in cubes and octohedra, and is the whitest of all known metals. It fuses at a bright red heat.

SILVER, OXIDE OF. There are three oxides of silver, viz.

| | |
|---|---|
| Suboxide | $Ag_2O$ |
| Protoxide | $AgO$ |
| Binoxide | $AgO_2$ |

Of these the protoxide only forms salts.

Suboxide of silver is produced as a grey film when ammonio-nitrate of silver is exposed to air. It is also produced when citrate of silver, (or any analogous organic salt of silver,) is exposed to the action of hydrogen at a temperature of 212°. The protoxide of silver contained in the citrate then loses one half of its oxygen, and the suboxide remains combined with one half of the acid. At least this is Wohler's theory; but the probability is that the acid is also decomposed, and the compound not exactly a subcitrate of silver.

Dr. Graham says, "The solution in water of the suboxide salt is dark brown, and the suboxide is precipitated black from it by potass; when the solution of the subsalt is heated it becomes colourless, and metallic silver appears in it. The salt dissolves of a brown colour in ammonia. Several other salts of silver, containing organic acids, comport themselves in the same way as the citrate when heated in hydrogen."

Protoxide of silver may be obtained by adding a dilute solution of caustic potass to a solution of nitrate of silver. It is thrown down as a dark olive coloured precipitate.

Protoxide of silver is, like oxide of lead, soluble to a slight extent in pure water, to which it communicates an alkaline reaction. The solution is reddened by exposure to light. This oxide is reduced to pure metal at a dull red heat, and to black suboxide by the action of light. It stains glass of a yellow colour, and is used in painting on glass and enamel. Ammonia dissolves it completely, and forms a colourless solution called ammoniacal oxide of silver.

The peroxide of silver is a curiosity of no value in photography.

Silver-Meter. This is an instrument for testing accurately the quantity of nitrate of silver in an old nitrate bath containing impurities which affect the S. G. of the liquid, and therefore render the hydrometer useless as a means of testing its strength in silver.

The principle on which this meter acts consists in ascertaining how much of a solution of pure chloride of sodium of definite strength is necessary to precipitate the whole of the silver contained in a definite quantity of the nitrate bath. The following is the mode of proceeding:—

Make a solution of pure chloride of sodium by adding pure hydrochloric acid to a solution of carbonate of soda until effervescence ceases, and the acid is a little in excess. Evaporate the solution to dryness, and fuse the pure chloride of sodium in a porcelain capsule over a spirit lamp. Then make a solution of it in distilled water of the strength of 17 grains of the salt to 12 fluid ounces of water. This is the standard test solution; which must be made very accurately. A fluid drachm of it will exactly precipitate half a grain of nitrate of silver.

In order to test the strength of the bath, put a small measured quantity, say a drachm, into a clean stoppered bottle, and add to it a little distilled water. Then add the test solution from a graduated measure, a little at a time, shaking after each addition and allowing the white chloride of silver to settle each time, until the salt ceases to produce any more cloudiness in the clear liquid. The quantity of the test solution employed, estimated at the rate of one drachm to half a grain of nitrate of silver, will then determine the exact quantity of nitrate of silver contained in a fluid drachm of the nitrate bath.

Mr. G. Wood, of 117, Cheapside, manufactures a neat form of apparatus on the above principle, by which the operator is saved all the trouble of calculation. We have one of these instruments, and find it of great use, and very accurate.

Sine of an Angle. The size of an angle does not depend upon the length of the lines which contain it, but upon their inclination to one another. This may be measured in a variety of ways. One mode is to find what is called the Sine of the Angle, which is done as follows:—

In either of the straight lines which contain the angle take any point P, and from P draw a perpendicular PN upon the opposite side. Then, if we call the angular point A, the ratio of the perpendicular PN to the hypothenuse AP, of the right angled triangle APN, is the sine of the angle at A.

It matters not where P is taken upon the line AP, for take any other point P′ and draw a perpendicular P′N′ upon the opposite side; then the triangles APN, AP′N′ are similar, and the ratio PN : AP is equal to the ratio P′N′ : AP′.

Since the perpendicular is less than the hypothenuse (except A be a right angle, in which case they are equal), the sine of an angle is a decimal fraction less than unity. It may be found by consulting a table of natural sines.

In old treatises on Trigonometry the sine is generally defined by reference to a circle of which the radius is unity, but that plan is now exploded. In the modern system of mathematics the trigonometrical ratios have nothing to do with a circle. The sine of an angle is not a line, but a ratio, or *number*, and has no linear dimension. If, for instance, a man wants half an orange he may say " Give me sine 30° of an orange," the sine of 30° being one half, or ·5.

SINES, LAW OF. The "law of sines" in Optics connects the angle of refraction with that of incidence, in the case of a ray of light which suffers refraction. *See* " Refraction."

SIZE. *See* " Gelatine."

SIZING OF PAPER. *See* " Paper Making."

SOAP. *See* " Saponification."

SODA. Na.O. Oxide of Sodium.

Sodium, the metal of which soda is the protoxide, has a rather less affinity for oxygen than Potassium, but if laid upon a piece of ice it immediately takes fire and burns brilliantly.

Soda, which is the oxide of the above singular metal, may exist either in a pure form, or as a hydrate.

Caustic soda is the hydrate of soda, and its formula is Na.O, HO. It resembles in most of its properties caustic potass; and is white, opaque, brittle, and deliquescent; also very soluble in water and alcohol. Its affinity for acids is rather less than that of potass.

Caustic soda is made from the common carbonate of soda used in washing, by driving off the carbonic acid by heat in contact with quick lime. The common carbonate of soda was formerly obtained from kelp, but is now manufactured almost exclusively from common salt mixed with sulphuric acid.

SOLARIZATION. *See* " Exposure."

Specific Gravity. The specific gravity of any substance is the weight of a unit of volume of that substance, at a temperature of 60° Faht.

The unit of volume, in the common table of specific gravities, is the volume of that quantity of pure distilled water which at 60° Faht. weighs 1000 grains; and in the same table the unit of specific gravity is 1000 grains.

The specific gravity of water is therefore 1.

If a vessel containing the unit of volume be filled with absolute alcohol, its increase in weight will be 794 grains, therefore the S. G. of absolute alcohol is ·794.

If the same vessel be filled with pure concentrated sulphuric acid, its increase in weight will be 1842 grains, therefore the S. G. of sulphuric acid is 1·842; and so on.

Specific Gravity Bottle. This is a glass bottle shaped like a decanter, and furnished with a stopper which is drilled with a hole, also with a counterpoise, or brass box filled with shot, which exactly balances it when empty. The specific gravity bottle holds exactly 1000 grains of pure distilled water at 60° Faht. Its capacity is therefore the unit of volume of the specific gravity table.

To use it, fill it quite full with the fluid to be tested, and put in the stopper. The superfluous fluid overflows through the hole in the stopper. Wipe the bottle quite dry, and weigh it, together with its contents, in a delicate balance, the counterpoise of the empty bottle being placed in the opposite scale. The number of grains required to be added to the scale which contains the counterpoise, and which consequently represent the weight of the fluid, divided by 1000, is its specific gravity.

Specific Heat. By the specific heat of a body is meant the time it takes to cool from a certain given temperature to another given temperature, when placed in vacuo in a polished silver vessel. By some writers the specific heat of a body is supposed to be its "capacity for heat," as if heat, which is the undulation of an ethereal medium, could be stowed away among the particles of a body. Surely the notion of "capacity for heat" is absurd. That different bodies should require different times to pass from one temperature to another involves no difficulty of comprehension, and specific heat is simply the measure of the time required.

Dr. Graham says, "Of all liquid or solid bodies water has much the greatest *capacity for heat;* hence the sea, which covers so large a proportion of the globe, is a great *magazine of heat,* and has a beneficial influence in equalizing atmospheric temperature. Mercury has a small *specific heat*, so that it is *quickly heated or cooled;* another property which recommends it as a liquid for the thermometer, imparting as it does great sensibility to the instrument."

The reader may amuse himself by trying to state in a different form, and on the assumption of the undulatory theory of heat, the *facts* implied in the above sentence.

The time which a body takes either to become colder or hotter depends in great measure on the condition of its surface. If the surface be smooth, polished, and white, the time is increased; if rough and black, the time is diminished. When an ethereal undulation strikes the surface of a body, it depends upon the condition of the surface whether the undulation be continued among the particles of ether within the body, or whether it be reflected among those which are external to the body; and conversely, when a body is contracting, and therefore radiating heat, it depends upon the condition of its surface, whether the undulations of the ether within the body be communicated to the ether without it, or returned by internal reflexion among the ether within it. A smooth polished surface is favourable to the reflexion of undulations, and unfavourable to their direct propagation. Colour is no doubt owing to a peculiarity of surface. *See* "Latent Heat."

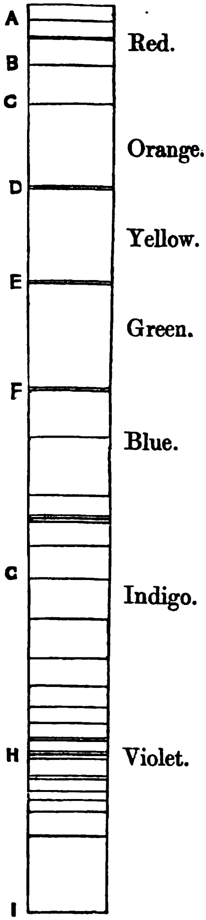
SPECTRUM. Suppose a small hole of *any* shape made in the window shutter of a darkened room, and that sunshine be admitted through it, and the light received upon a white screen, placed perpendicularly to the line joining it and the hole; then, a *round* image of the sun will be formed upon the screen, the diameter of the image depending upon the distance of the screen from the hole. Observe that *whatever* may be the *shape* of the hole, the image of the sun will be *round.* A triangular hole would not give a triangular image, nor a square hole a square image; the sun being round, its image is round; for the image is not produced by a *ray* of sunshine which enters through the hole and falls upon the screen, producing a spot of light the same shape and size as the hole, but by *pencils* of light which diverge from every part of the sun, and after crossing each other in passing through the hole, proceed till they reach the screen, where they form a *round* image of the sun, the size of which increases as the distance of the screen from the hole increases. Thus, the sun being about half a degree in angular diameter, if the screen be placed 10 feet from the hole, the sun's image will be about 1 inch in diameter; if 20 feet from the hole, 2 inches in diameter, and so on.

This being understood, let a glass prism be placed with its edge immediately behind the hole. Then, since white light is not homogeneous, the pencils will all be decomposed by refraction through the prism into pencils of the different coloured lights of which white light is composed; so that the screen, instead of receiving a single round image of the sun in white light, will receive upon a different part of it as many different coloured *round* images of the sun as there are different kinds of light in white light separable by refraction. These images will partly overlap one upon the other, and produce a long image of the sun, having belts across it of different colours, arranged in the following order, (if the refracting angle of the prism be suitably taken,) viz., red, orange, yellow, green, blue, indigo, violet; which colours are called the "prismatic colours," and the entire coloured image the "prismatic spectrum." Should, however, the refracting angle of the prism be too small, there will be a space of white light in the centre of the spectrum, produced by the coincidence of a portion of each of the coloured images.

The reader will perhaps find this account of the way in which the prismatic spectrum is generally produced somewhat different from the accounts given of it in popular treatises on Optics; these popular explanations generally proceeding on the assumption that the light which is admitted through the hole is a single beam of light,—which is manifestly incorrect. Every photographer knows that an *image* is formed of external objects by light admitted through a small hole in the front of a dark box, and received upon a focussing screen; and that this is true, however small the hole may be and whatever its shape. We have, therefore, to deal with an *image* of the sun, and not with a single ray of white light.

It appears, then, that when the spectrum is formed by admitting the light through a hole, however small, the bands of different colours contain an admixture of lights of different refrangibilities. In order to obviate this evil, M. Fraunhofer admitted the light through a long and extremely fine slit, instead of a hole, and placed the prism with its edge parallel to the slit, *and at a considerable distance from it.* But even this arrangement is not sufficiently exact, for the additional precaution must be taken of covering the prism with an opaque diaphragm, having an extremely fine slit parallel to the edge of the prism and therefore parallel to the other slit, so that the light from the first slit may also pass through the second slit. In this way the spectrum is rendered nearly pure, and the different parts of it free from the admixture of other colours. And here it is important to observe that in the experiments of Sir David Brewster, in which he detected white light in every part of the prism in a state of admixture with his supposed simple colours, red, blue, and yellow, allowance had not been made by him for the impurity of his spectrum, so that his conclusions that Newton's theory was wrong and that the seven colours of the spectrum may be reduced to three was founded on experiments conducted in ignorance apparently of an elementary principle in geometrical optics.

When a pure spectrum is examined by a telescope, it is discovered to be intersected by a great number of dark lines, as shown in the following figure, and which are called "Fraunhofer's Lines," he having first discovered them. There are nearly 400 of these lines.



These lines are produced by the interference of undulations of light. In the spectra produced by light from different sources the lines do not occur in the same order; neither do they occur at the same relative distances when light from the same source is refracted through prisms made of different materials. In the light from the sun and planets the spectral lines occur in the same order; but in the spectra formed by light from the fixed stars, or by the electric light, or by light produced by the combustion of different substances, the spectral lines do *not* occur in the same order, nor are they equally numerous.

With respect to the calorific, luminous, and actinic properties of different parts of the solar spectrum;—It has been shown in the article on light, that light, heat, and actinism are most probably undulations in the same ethereal medium, differing only in the length of the wave; and it is found by experiment, that both heat, light, and actinism, are capable of producing chemical changes in bodies; so that the term "actinism" merely means that *certain* substances are chemically affected by *certain* rays (called the actinic,) residing at a *certain* part of the spectrum.

It is therefore somewhat unscientific to call certain rays "actinic" because they produce chemical changes in certain bodies, and then to say *generally* that the chemical rays chiefly lie at the violet part of the spectrum, when we know that *every* part of the spectrum is capable of producing important chemical changes in some substance or other. To say that the heat rays reside mostly at the red end of the spectrum, luminous rays mostly in the yellow part, and chemical rays mostly in the violet part, is so far unscientific that it is not the statement of a universal law; for the effects exhibited by the different parts of the spectrum upon a substance placed in it, *depend upon the nature of that substance, and are different with different substances.* This being the case, we have not included in the foregoing figure of the spectrum the three wave lines of light, heat, and actinism, with which it is generally adorned in popular works on photography.

In the following table the lengths of the waves corresponding to the principal lines of the solar spectrum are expressed in millimètres.

| | | |
|---|---|---|
| Extreme red | ·00075 | millimètres. |
| A | ·00074 | „ |
| B | ·0006879 | „ |
| C | ·0006559 | „ |
| D | ·0005888 | „ |
| E | ·0005265 | „ |
| F | ·0004856 | „ |
| G | ·0004296 | „ |
| H | ·0003963 | „ |
| I | ·00037 | „ |
| Extreme violet | ·00036 | „ |

Speculum Metal. This is generally a compound of about 6 parts copper, 2 parts tin, 1 part arsenic. It is used for metal reflectors. The great reflector of Lord Rosse's telescope is made of 126·4 parts copper and 58·9 parts tin, without the addition of any arsenic.

The word "Brass" was omitted in the letter B. We may observe in this place, that brass is a compound of copper and zinc, with the addition sometimes of a little lead, tin, and iron. The latter metal should not be introduced in the brass used for philosophical apparatus. The proportions of the metals in brass for turning are as follow:—

| | |
|---|---|
| Copper | 61·6 parts. |
| Zinc | 35·3 „ |
| Lead | 2·9 „ |
| Tin | 0·2 „ |

Spermaceti. This substance is sometimes used instead of wax in photography. It is a soft white crystalline substance, precipitated from the oil of the spermaceti whale on cooling after the death of the animal. It is purified by pressure and boiling in a weak solution of caustic alkali, after which it is washed, melted in boiling water, and cast into blocks or cakes. It is soluble in about 50 parts of alcohol S.G. ·820. Pure spermaceti is certainly better than impure wax in photography; and, from its being softer and more easily melted, it penetrates the pores of paper more readily.

STANDARD GOLD. A sovereign weighs 5 dwts. 3·27 grains, and is composed of 11 parts gold to 1 part copper. The standard gold of France contains 9 parts gold to 1 part copper.

STANDARD SILVER. Standard silver consists of 11·10 parts of silver and ·90 parts of copper. A shilling weighs 3 dwts. 15·27 grains.

STANDARD SPIRIT. A mixture of alcohol and water, having the S.G. ·92 at 62° Fahrenheit. It contains very nearly equal parts of absolute alcohol and water.

STARCH. $C_{12} H_{10} O_{10} = 12$ atoms of carbon and 10 of water. This substance occurs abundantly in vegetables, and is generally obtained by steeping the powdered grain or seed, or the raspings of the root, bulb, or stem in cold water, which becomes white and turbid, and, after being strained, deposits the starch in the form of a white granular substance which is then dried at a gentle heat.

Common starch is manufactured from flour. Arrowroot, tapioca, and sago are different forms of starch. Starch is frequently made from potatoes.

When starch is heated to a certain temperature, it becomes converted into a gum called "Dextrine" (*q. v.*). It forms a blue compound with iodine, called iodide of starch, an aqueous solution of which is bleached by light: it combines also with sulphuric acid, forming sulphate of starch, and with lime and baryta; also with tannin. Starch becomes converted into sugar by the action of an azotized principle, called "Diastase," and also by the action of dilute acids.

Starch is insoluble in cold water, alcohol, and ether. When boiling water is poured upon it, clots are formed which cannot afterwards be diffused through water. Solution of starch is best made by pounding the starch, and mixing it thoroughly with cold water; then adding hot water, or boiling it, stirring it uniformly until a gelatinous mixture is obtained. A solution of starch is supposed to consist of the granules considerably distended and diffused through the water. When, however, the indurated envelope of the starch granule bursts, the contents are distributed through the water, and form a transparent gelatinous liquid which, on cooling, throws down an opalescent deposit. The substance held in solution in the clear liquid has been called "AMIDINE."

STEARINE. (Gr. στεαρ suet.) The principal constituent of solid fats. It is composed of stearic acid in combination with glycerine.

STEREOSCOPE. (Gr. στερεος solid, σκοπεω I see.) This is an instrument for exhibiting two plane perspective views of an object, taken from different stations, as one having the appearance of solidity. It is the invention of Professor Wheatstone, and was first made public and the theory of it explained by him in the year 1839. At that time the pictures were exhibited by means of reflectors, but the inventor suggested that lenses might be used instead. Some years after this, an instrument was brought out by Sir David Brewster, in which small photographic pictures are placed in a dark box, and viewed through half-lenses mounted in tubes; and, soon after the introduction of that very imperfect instrument, Messrs. Knight, of Foster Lane, patented an improved form of stereoscope, in which *large* semi-lenses are used, mounted in the front of the instrument, without tubes; and this, in the course of time, became so generally preferred to the other, as to supersede it to a great extent. But it was soon found that the *semi*-lenses, whether large or small, produced an unbearable amount of distortion in the solid picture, making straight lines look as if they were concave to the spectator; so, in order to obviate this evil, *whole* lenses were tried, and these were found to answer in certain cases. But as the theory of the lenticular stereoscope is even now but little understood by opticians or the public at large, it was not perceived that, in order to render that form of instrument perfect, it was necessary not only to use whole lenses to get rid of the distortion, but to take the pictures in a camera suitably constructed, and mount them properly. The popular form of the stereoscope as manufactured by Mr. Knight, and called by him the Cosmorama Stereoscope, is however, notwithstanding its defects of principle, a very amusing instrument, and it is not till the spectator has become familiar with the true principles of stereoscopic representation that the defects are perceived. We shall endeavour, then, in the present article to explain the theory of the stereoscope in a clear and intelligible manner. But the reader must first consult and study the article on "Binocular Vision," for it is here assumed that the principles of binocular vision are clearly understood.

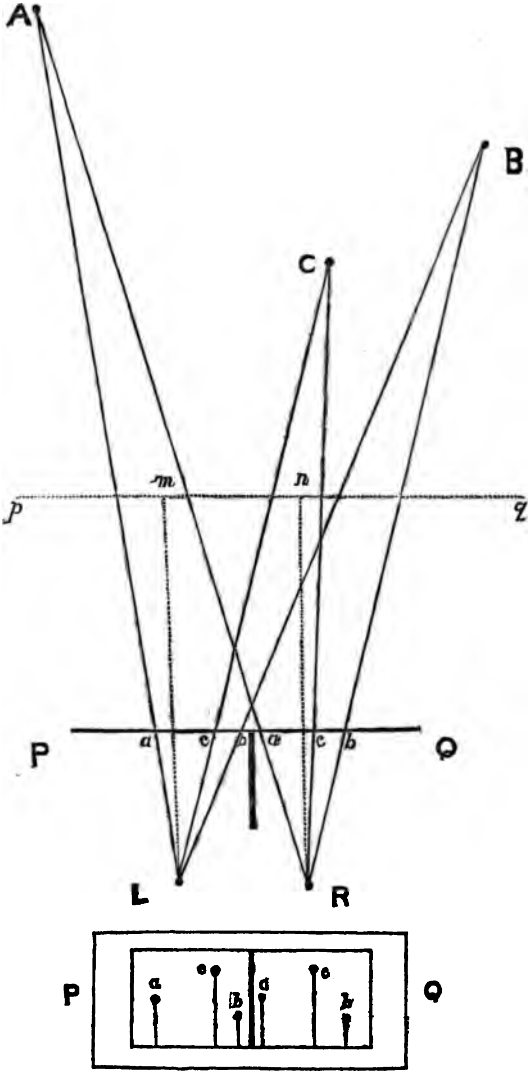
### *Theory of the Stereoscope.*

The theory of the stereoscope consists in showing—first, how the instrument may be employed to represent things *truthfully* as we see them in nature; secondly, how it may be employed to represent them *falsely* as we *should* see them if our eyes were wider apart; and, thirdly, to explain how it happens that distortion is introduced by using an instrument of improper construction—straight lines being represented by curves, and so on.

Let L, R be the eyes of a spectator; A, C, B lamp posts of different heights having lights, or luminous points, A, B, C, at the top. Draw the visual rays L A, L C, L B, R A, R C, R B. Cut them by a vertical plane P Q parallel to the line which joins L and R. Then the points *a*, *c*, *b*, *a*, *c*, *b*, where the visual rays pass through this plane will be the images of A, B, C, as seen from the stations L and R, P Q being supposed to be the plane of a perspective picture. (*See* "Perspective.") If the plane P Q be placed as shown in the figure, so that the perspective view as seen from L may be completely exterior to that seen from R, the pictures will be as represented on a card beneath L and R. (*See* the Lower Part of the Figure.)

Now if the perpendicular distance between L and the plane P Q be such that the points *a*, *b*, *c*, can be distinctly seen by an eye at L, —that is to say if this perpendicular distance be not *too short* for distinct vision, and if we place the card P Q before the eyes, as in the figure, the right picture being cut off from the left eye and the left picture from the right eye by a partition, as shewn in the figure, then instead of seeing two pictures *abc*, *abc*, only one image will be seen, and that one image will appear to be the lights A, B, C in their natural position, and at their true distance. For when the left eye is directed to *a* along the line L*a*, the right eye is directed to *a* along the line R*a*, and the optic axes L*a*, R*a*, being produced meet at A, so that the spectator instead of seeing two images *a*, *a*, upon a plane P Q sees one image A at the true distance and in the true position of the light A. Similarly with respect to the other images *b*, *c*, *b*, *c*, which combine and produce single images at B and C.

It is evident that the perpendicular distance of P Q from L or R, (which we will call F,) will depend upon the size of the angle A L B, or A R B; for the smaller that angle is the further the plane P Q may be placed from L and R, and therefore the more easy it will be-


A
B
C
m
n
p
q
P
Q
a
c
b
a
c
b
L
R
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a
c
b
a
c
b

come for the images *a, b, c*, to be seen distinctly by persons of ordinary vision. Most persons can see a thing distinctly at a distance of 8 inches. If then F=8, the angle ALB may be about 16°.

Now we come to the principles of the stereoscope.

Suppose we place at each of the stations L, R, a photographic camera, the lens of which is 8 inches focus, and adjusting these cameras *with their axes strictly parallel*, take the pictures of A, B, C, (including an angle of 16°). Then when these pictures are properly mounted they will be identical with the perspective views of A, B, C, upon the plane PQ; and if placed in a box having a partition in the middle and holes to look through at P and Q *at a distance of* 8 *inches from the pictures*, the spectator on looking through the holes will perceive a single image of the points A, B, C, at their true distance and in their true relative positions.

A box so constructed may be called a "Simple Stereoscope," because it does not involve the use either of lenses or reflectors, and the pictures properly taken and viewed in it have the inexpressible charm of truthfulness.

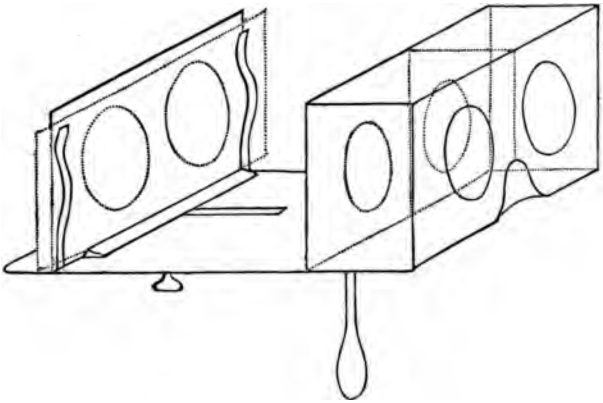
Of what use then, it may be asked, are lenses and reflectors? To this question we will now endeavour to reply.

In the first place the simple stereoscope, when adapted to persons of ordinary sight, does not include an angular field of more than 16°; which is in general too small. A photographic picture should include at least an angular field of from 25° to 30°. This can only be effected by bringing the pictures as near to the eyes as 5 inches, at which distance most persons find a difficulty in seeing them distinctly; but this difficulty is overcome by placing a *whole* lens of 5 inches focus in each of the holes L, R, and viewing the pictures, (which must be taken with a lens of 5 inches focus,) through them. This instrument is called the "Lenticular Stereoscope." In the following description of it we shall recapitulate what has been said, and discuss the matter more fully.

### *The Lenticular Stereoscope.*

This is an instrument for exhibiting a pair of stereoscopic pictures, which include an angular field of about 26°, and have been taken in a stereoscopic camera provided with lenses of 5 inches equivalent focal length, having their axes parallel, and mounted at a distance L R (=2½ inches) from centre to centre. [The reader will observe that the stereoscopic camera described at page 67 of this work is calculated to exaggerate the relief of objects, because the stations are taken at 5 inches apart; in all other respects however the principle of it is correct.]

The best construction of the Lenticular Stereoscope for exhibiting paper pictures, (kata-positives,) is shewn in the following figure, which scarcely needs explanation.



The *whole* lenses fixed in the front of the box are placed 2½ inches from centre to centre, and should not be less than 1 inch in diameter. They should be of 5 inches focus, and achromatized meniscus lenses with the hollow side outwards, in fact the same lenses as those used for taking the pictures, which may be unscrewed from the camera, and screwed to the stereoscope. The back of the solid box should have holes in it as represented by the dotted lines, and also a partition in the middle. The holes should be 2½ inches from centre to centre, and their diameter determined by trial. If the front box be 2½ inches deep, the back diaphragms should be a trifle more than 1 inch in diameter. A set of diaphragms of different sizes to fit in the back of the front box would be a useful addition to the instrument. The inside of the front box should be properly blackened. The pictures may be circular, mounted 2½ inches from centre to centre and about 2¼ inches in diameter. By the centre of each picture is meant the point where the axis of the lens cuts it. In mounting the pictures this is the point to be considered, and no reference whatever is to be made to any of the objects in the pictures. These are always nearer together than 2½ inches, when mounted. The mounted pictures are fastened by springs to a slider which moves in a slit in the bottom of the stereoscope, so that the distance of the pictures from the lenses may be varied to suit different sights, or for trying experiments; the proper distance, however, being 5 inches, which is the focal length of the lenses. The pictures should be mounted upon black cardboard. In order to make the objects appear more distant than the cardboard, that is, in order to make them appear as if viewed through a circular hole nearer to the spectator, the following rule in mounting them should be attended to. Just before trimming the edges, mount them temporarily $2\frac{1}{2}$ inches from centre to centre, upon a piece of cardboard, with pins at the corners; then measure the distance between the nearest object in each picture, (this will be less than $2\frac{1}{2}$ inches, probably not much more than $2\frac{1}{8}$ inches,) and take a dimension a little *less* than this for the diameter of the pictures. With half this diameter as radius, and the centre of the picture as centre of the circle, strike a circle on each picture, which will be the margin required.

In conclusion, we would observe that the object of taking the lenses as large as an inch in diameter is *not* that the margins of the lenses may be looked through, but simply because when they are too small their circumferences are seen by the eyes and form two intersecting circles upon the solid picture. Were it not for this circumstance the lenses need not exceed half an inch in diameter.

The stereoscope for exhibiting transparent pictures, (dia-positives,) is of the same general form as Knight's Cosmorama stereoscope, the the other points being the same as that of the Stereoscope described above.

It now only remains to explain the exact effect of the lenses upon the pictures. Turning to the figure at the commencement of this article; if a lens of focus F were placed at L, and the eye pressed close to it, a pencil diverging from *b* would after refraction through the centre of the lens be converted into a pencil of parallel rays, without suffering deviation, so that the eye would see the point *b* in the same direction as if no lens were interposed, that is along the line L*b*B, but would have less difficulty in bringing to a focus upon the retina a parallel pencil than one diverging from a point so near as *b*. When therefore the eye is placed so close to the lens as to see things exactly through its centre there is no magnification. If however the eye be placed at a little distance from the lens it does not look at the side objects exactly through the centre, and therefore the lateral pencils suffer a slight deviation, which increases the apparent angle ALB, and produces magnification, which may however be counteracted by putting the pictures a little *further* from the lens than its focal length.

If then we leave out of consideration the unavoidable defects of all lenticular optical instruments, it appears that the form of stereoscope that has been described exhibits pictures, *when properly taken*, in such a way as to represent objects precisely as they would appear to unassisted vision, so that natural truth is perfectly realized. And the reader will particularly observe that in this form of stereoscope the images are not displaced or caused to overlap by any optical contrivance. How then, it may be asked, is the effect produced?

Let us examine carefully the pictures upon the card PQ.

In the first place the points *a,a,*—*b,b,*—*c,c,* are upon the same horizontal lines, which is simply because the cameras had their axes parallel, and not converging to a point; (*See* remarks on page 65).

In the next place, if we measure the distances *aa*, *bb*, *cc*, we find *aa* the *greatest* because A is the *most distant* object; *bb* the *next* because B is the *next* object in point of distance; and *cc* the *least* because C is the *nearest* object. But all these distances are less than LR. If, however, in addition to the three lamps, a fixed star D were introduced in any part of the picture, the visual rays LD, RD would be parallel, and the points *d,d,* where they cut the pictures would be at the same distance apart as L and R. If then we join L,R, with points *c,c,* nearer together than L and R, (and in the same plane with them) the lines L*c* R*c* meet at a finite distance C; but if we join L,R with points *d,d,* at the same distance apart as L and R the lines L*d*, R*d* are parallel, or only meet at an infinite distance. Hence it follows that in mounted stereoscopic pictures the furthest objects are the widest apart, and the nearest objects the nearest together; objects at an infinite distance only being as far apart as the distance between the eyes. These considerations will explain at once why it is that there is no necessity for displacing the images of the pictures by half lenses; the objects being sufficiently displaced by the perspective in the pictures themselves, and any further displacement being wrong in principle. The Brewsterian stereoscope has therefore been a step in the *wrong* direction, and the error has to be pointed out to the public, and the work begun over again.

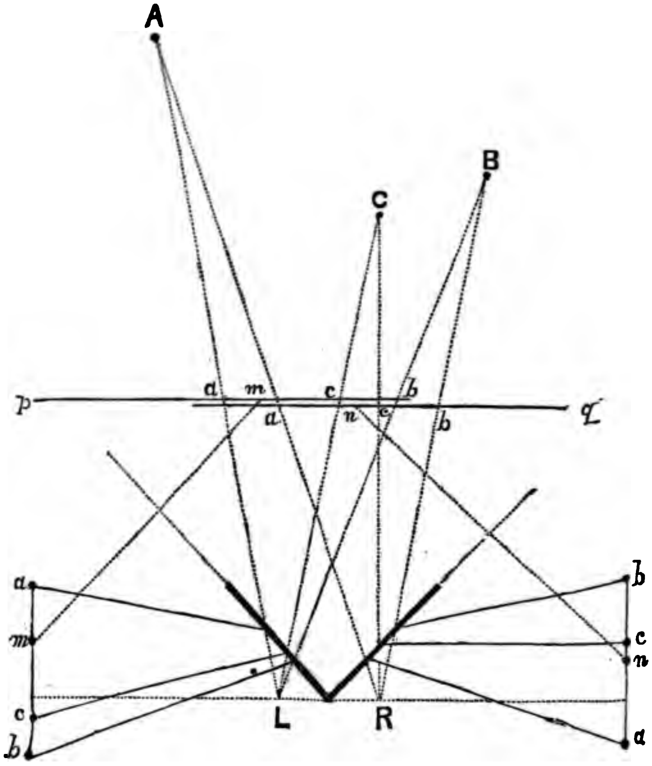
We have now done with the Lenticular stereoscope. Its defects are those which are inseparable from all optical instruments in which lenses are used, and the pictures are so small that it is impossible to include in them the same amount of detail as in larger pictures. But at the same time for *many* purposes the smallness of the pictures, involving but a small expenditure of material and permitting the use of a light and portable form of apparatus in which both pictures may be taken simultaneously, is a real advantage.

We now proceed to an account of the reflecting stereoscope.

### *The Reflecting Stereoscope.*

Referring to the figure at the commencement of this article. If the visual rays are cut by a plane *pq* instead of PQ the pictures will be larger than before, and instead of being entirely exterior one to the other, will overlap, and be mixed together so to speak. But if we take the pictures in cameras placed at L and R, with lenses of focal length L*m* or R*n*, having their axes parallel, and then by means of reflectors throw the virtual images of the pictures so taken into their proper positions on the plane *pq*, and view these images by eyes at L and R, a truthful solid image will be produced, as in the former case; because the left eye will not then see the picture from the right station, nor the right eye that from the left station.

The arrangement is exhibited in the following figure :—



After what has been said on the subject of the lenticular stereoscope the foregoing figure will only require a few words of explanation.

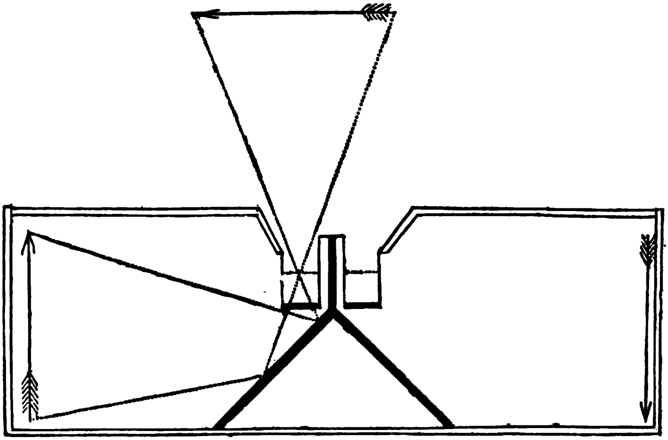
The reflectors are placed at right angles to each other, and the pictures at right angles to the dotted line, or base, passing through the angle formed by the reflectors, the distance from that angular point being equal to L*m* or R*n*, and therefore to the focal length of the lens with which the pictures are taken. The distance of the middle points of the pictures, (that is the point where the axis of the lens cuts them,) viz. *m*, *n*, from the dotted base is half the distance LR. The pictures are taken in a non-reversing slide, so that their images on the plane *pq* as seen in the reflectors, are not reversed; this is an important point to attend to.

The image of the left hand picture is *pmb*; that of the right hand picture *qna*, the lines *pb*, *qa*, being separated for the sake of distinctness, but in point of fact the images lie on the same plane. The left eye cannot of course see the image of the right picture, and *vice versâ*, so that the images overlapping produce no confusion. The image of each picture and the picture itself are symmetrically situated with respect to the reflector by which it is viewed.

All this being understood we come to the mode in which the instrument acts.

A pencil from *b* in the left picture, after reflexion at the left mirror enters the left eye *as if* it had come from the point *b* on the line *pb*; the point *b* is therefore seen by the left eye in the direction L*b*. Similarly, a pencil from *b* in the right picture, after reflexion at the right mirror enters the right eye *as if* it had come from the point *b* on the line *qb*; the point *b* is therefore seen by the right eye in the direction R*b*. These two lines R*b*, L*b*, are the instantaneous directions of the optic axes, and being produced they meet at B, which is the true position of the object B. Similarly with respect to the other objects A, C. Therefore by means of the reflecting stereoscope a true representation is afforded in natural relief, and actual distance, of the objects in the picture.

The reflecting stereoscope is not open to any single practical or theoretical objection. As an optical instrument it is *absolutely perfect*, being subject to no defects of distortion or aberration. For any scientific purpose, therefore, the reflecting stereoscope should always be preferred to the other. The reflectors may be made of polished speculum metal if objection be raised to glass mirrors, and the pictures may be taken simultaneously in a camera with double lenses 2½ inches from centre to centre, constructed as shown in the following figure, which explains itself.



In this double-reflecting camera the non-reversing slide need not be used.

It now only remains to add a few remarks on taking stereoscopic pictures.

In the first place, the effect of taking the stations wider apart than 2½ inches (the parallelism of the cameras being still preserved) is to bring the near objects in the solid image nearer to the spectator than they were before, and nearer than they are in nature, while the most distant objects remain in their true position. This may be in some cases allowable, because the stereoscope is intended to serve certain educational purposes; and it may happen sometimes that, by giving bolder relief to objects than they really have, the thing to be explained may be rendered more intelligible.

In the next place, the effect of directing the axes of the lenses to the same point at a finite distance introduces distortion in the solid image, unless the pictures are placed in the stereoscope at the same angle of inclination to one another as the focussing screens of the cameras. When, however, the stations are taken very wide apart (several feet, for instance), if the parallelism of the cameras be preserved, the pictures are partly thrown outside the focussing screen, besides being taken with very oblique pencils; so that, when correct principles of operation are once departed from, for any purpose, other changes in the arrangement of things become necessary. We cannot, however, within the compass of the present work, do more than explain completely the theory of the *correct* form of the instrument; it would require a separate treatise to follow up the subject through all the modifications which it may assume. Enough has been said to enable any intelligent reader to think out the remainder for himself.

In printing stereoscopic pictures from a negative, taken in a double-lens camera, by contact in the pressure frame, it must be borne in mind that the print requires to be cut in half and the pictures transposed, in order to bring the picture that was taken from the left station before the left eye in the stereoscope, and *vice versâ*. If this be not attended to, a pseudoscopic effect is produced.

In printing stereoscopic transparencies by means of a lens, the following plan may be adopted:—

A copying camera, rather more than double the length of the stereoscopic camera, is provided, and the lenses of the stereoscope are fixed in the middle of it; there must also be a partition dividing the camera in half lengthways. In this way the left lens copies the left picture at the same time that the right lens copies the right picture. The negative must be placed with its back next to the lenses at one end of the box, and the sensitive positive plate in a common slide at the other end. The camera is then directed towards the sky, and the wet collodion process employed. An exposure of a few seconds is sufficient. The positive need not be divided and the pictures transposed, for, when placed in the stereoscope with its plane side next to the lenses, and a ground glass laid against the film, the pictures are in their right position to be viewed. By putting the lenses midway between the negative and positive, the positive becomes of the same size as the negative. The best lenses to employ are portrait lenses, with a small stop between the back and front lenses in each.

In the stereoscopes and stereoscopic pictures commonly sold there are the following serious defects:—

1st. The pictures are frequently taken in converging cameras, and then mounted upon the same flat surface.

2nd. The pictures are generally mounted so wide apart that the most distant objects in each are wider apart than the distance between the centres of the eyes.

3rd. An attempt is made to obviate the evil produced by the above practice, by using *semi* lenses in the stereoscope which displace the images. This of necessity produces distortion, because straight lines are always represented by curves when the outside part of a lens is used to view objects through, instead of the centre.

4th. The displacement of the images is in general so great as to cause the optic axes to converge to points situated within two or three feet from the nose, instead of the true distance of the objects. The effect of this is to make the solid picture look like a small model of the object, which the spectator could, if he chose, lay his hand upon, or touch with a yard measure.

Lastly. The focal length of the lenses of the stereoscope is in general 6 inches, while that of the lenses in the camera is only 4 inches. This makes objects appear much smaller than they do in nature.

To sum up. The common stereoscope and pictures make objects look very near, very small, and distorted. The stereoscope described and recommended in the present article makes them look of their *true* size, at their *true* distance, and without perceptible *distortion*.

In this article the term "solid image" has been several times used. The employment of this term may perhaps be thought objectionable; we do not, however, know of a better, and if the thing meant has been clearly understood, the end has been answered.

STEREOMONOSCOPE. This is an instrument invented by M. Claudet for exhibiting upon a screen of ground glass a single picture having the true effect of solidity. This result, which may at first sight appear paradoxical, is accomplished thus:—

A pair of stereoscopic pictures is first taken in the usual way. Magnified images of them are then thrown, by means of a pair of lenses (one for each picture) upon the same part of a large upright screen made of coarsely ground glass, the axes of the lenses converging at a suitable angle. The spectator then stands at a distance of a few feet on the opposite side of the screen, and looks with both eyes at the image formed upon it. The image formed by the right hand lens is seen by the left eye, and that formed by the left hand lens by the right eye, in consequence of the roughened state of the glass, which is filled with minute transparent spots. A true stereoscopic effect is said to be produced in this way by the combination of the images.

STONE BLUE. A mixture of indigo and starch, moistened with water, made into cakes, and dried. Sometimes Prussian blue is used instead of indigo.

SUCCINIC ACID. (Latin, *Succinum* amber.) An acid obtained rom amber by distillation with sulphuric acid. It is one of the most powerful organic acids, and forms salts with the alkalis and metallic oxides called succinates. Succinate of silver is darkened by light, and has been used in photographic experiments.

SUGAR. This is a substance extracted from the sweet juices of a great number of plants. There are two principal varieties, viz., cane sugar and grape sugar. The latter variety is described in a separate article, *q. v.*

Cane sugar is for the most part obtained from the sugar cane, but it exists also in beet-root, in the sap of certain species of maple, and in the stem of indian corn. It is crystallizable, and the crystals usually occur as six-sided prisms with flat and irregular ends. It is soluble in about one-third of its weight of water, but more sparingly in alcohol, boiling absolute alcohol only taking up about the one-eightieth part of its weight of cane sugar. It is dimorphous, existing in the crystalline form as sugar candy, or white sugar, and in an amorphous concrete state as barley sugar, which is produced by rapidly boiling down the syrup till it solidifies in a transparent mass on cooling.

Cane sugar is powerfully acted on by sulphuric acid, which takes a portion of the elements of water from it, and produces a black magma consisting chiefly of carbon. It is converted into grape sugar by the action of dilute acids, and also of certain azotized principles called "ferments."

Cane sugar combines with some of the alkalies and metallic oxides.

SUGAR OF LEAD. Acetate of Lead; *q. v.*

SUGAR OF MILK; Lactine. A sugar contained in whey, and obtained by evaporating the whey to a syrup, and allowing it to crystallize. It has a feebly sweet taste, is very hard, and feels gritty between the teeth. It is slow and difficult of solution in cold water. It combines with protoxide of lead.

SULPHATE OF IRON. There are two sulphates of iron, the protosulphate, or sulphate of the protoxide, and the persulphate, or sulphate of the sesquioxide.

*Proto*-SULPHATE OF IRON. $Fe. O, S O_3 + 7 H O = 139$. This salt, sometimes called "Green vitriol," is obtained by acting on iron filings with dilute sulphuric acid, evaporating, and crystallizing. When pure, and free from persulphate, the crystals are of a bluish green colour, free from red stains, and in the form of oblique rhombic prisms. They are insoluble in alcohol, which deprives them of water and precipitates the salt as a white powder;—and soluble in rather more than an equal weight of water. In dry air they effloresce but in moist air become reddened and oxidized into a persulphate. They fuse in their own water of crystallization.

Native green vitriol is frequently found in coal mines associated with iron pyrites.

Protosulphate of iron forms double salts with the sulphates of ammonia and potass. Its aqueous solution absorbs binoxide of nitrogen, and becomes of a deep olive colour.

Protosulphate of iron is a powerful deoxidizer, and is used extensively in Photography as a developer. When oxidized it becomes converted into persulphate. The proto- and persulphates are capable of crystallizing together, and forming a double salt of a grass-green colour, while the pure protosulphate is of a bright *bluish* green.

*Per*-SULPHATE OF IRON. There are several persulphates of iron, some of which are soluble in water, others not, yielding either a brown mass, or dingy grey salt. They are compounds of sulphuric acid with Sesquioxide of iron, $Fe._2 O_3$.

SULPHATE OF SILVER. $Ag. O, SO_3$. Silver may be dissolved in its own weight of boiling sulphuric acid. A white salt is formed, which is sulphate of silver. It is also produced by adding sulphate of soda to a solution of nitrate of silver. It is soluble in 90 parts of cold water ; and also in ammonia, which forms a double salt "ammonio-sulphate of silver."

Nitrosulphuric acid formed by dissolving 1 part of nitre in 10 of sulphuric acid dissolves silver at a temperature below 200°, and the solution may be moderately diluted before sulphate of silver separates from it.

SULPHIDES. Sulphur combines in various proportions with most of the metallic and non-metallic elements, and forms compounds called "sulphides."

SULPHIDE OF AMMONIUM. *See* "Hydrosulphate of Ammonia."

SULPHIDE OF SODIUM. *See* "Artificial Ultramarine."

SULPHIDE OF SILVER. $Ag. S$. This fine mineral occurs native in various forms, sometimes crystallized in cubes, octohedra, and dodecahedra. When combined with sulphide of antimony it forms the red or ruby silver ore. It may be produced easily as a grey crystallizable compound, by heating together finely divided silver and sulphur, the compound being much more fusible and softer than silver.

Sulphuretted hydrogen, and hydrosulphate of ammonia, throw down a yellowish black precipitate from a solution of nitrate of silver, which is believed to be sulphide of silver.

Sulphide of silver is decomposed by a solution of chloride of copper containing common salt, the products being chloride of silver and subsulphide of copper. No decomposition, however, takes place unless salt be present.

**SULPHUR.** S=16. A yellow, crystallized elementary body, found chiefly in the neighbourhood of volcanoes. About 20,000 tons are consumed annually in England, and are imported chiefly from Sicily. It exists abundantly in combination with lead, copper, and iron.

Sulphur is highly combustible, and burns with a blue flame, producing sulphurous acid. It is insoluble in water, and permanent in the air. It volatilizes at 180°, and fuses at 220°, When heated to 300°, it becomes viscid and of a brown colour; if it be then poured into warm water it becomes soft like wax, and may be used for taking impressions; it becomes hard when cold.

Sulphur is soluble with difficulty in alcohol, but is more soluble in sulphuric ether, and still more so in volatile oils, turpentine, and alkaline solutions. Milk of sulphur is sulphur precipitated from an alkaline solution by an acid.

**SULPHUR TONING.** When an argentine photograph having the reddish tint produced by the combination of suboxide of silver with organic matter is placed in water containing a small quantity of sulphide of ammonium, the tint gradually changes from red to purple, and thence to green-yellow. This is called sulphur toning, the yellow substance being supposed to be sulphide of silver in an allotropic state; or it may possibly be a bisulphide of silver; or a double sulphide of silver and ammonium. A similar result occurs when the print is placed in a bath of hyposulphite of soda containing unstable sulphur salts, or unstable compounds of sulphur and oxygen, or free sulphur in a nascent state or state of fine division, exhibiting a milky turbidity in the bath produced by the addition of an acid to it.

The chemistry of the sulphur toning of a red argentine photograph, although probably a very simple matter, has not yet been investigated by any chemist of eminence, and the subject clearly made out, although one of great importance, for thousands of pounds are annually wasted by photographers in the production of perishable prints.

The ordinary fading of positives appears to be nothing more than the sulphur toning process carried to the yellow stage, in consequence of the presence of a destructive sulphur salt which cannot be removed from the paper. The combination of organic matter with the silver may have something to do with the result, and with the composition of the yellow substance. Photographs of a black tint, produced by development, and containing a much greater quantity of material than sun-prints, and that in a form much more nearly metallic, are found to be vastly more permanent then the latter.

SULPHURETTED HYDROGEN. *See* "Hydrosulphuric Acid."

SULPHURIC ACID. OIL OF VITRIOL. $SO_3$; or when hydrated, $HO, SO_3$.

This important article of manufacture, of which nearly a hundred thousand tons are made annually in Great Britain, is in general produced by burning together in a furnace a mixture of sulphur and nitre, the proportions varying from the one-eighth to the one-twentieth part of nitre.

The fumes are collected in immense leaden chambers, the bottoms of which are covered with water, which absorbs the vapour and becomes impregnated with sulphuric acid. When the water has acquired the S. G. of about 1·25, it is drawn off and evaporated by boiling in shallow leaden vessels till it acquires the S. G. of 1·7, when it would begin to act upon the lead. The evaporation is then completed in platinum vessels till the acid reaches the S. G. 1·845. The manufacture is then finished and the concentrated acid is transferred to carboys, (large glass bottles covered with wickerwork,) which contain 100 lbs.

Sulphuric acid of the S. G. 1·845 contains anhydrous sulphuric acid $SO_3$ plus one atom of water. It is a limpid, inodorous, colourless, and very heavy liquid of an oily consistence. It boils at a heat of 620°, and distils over without decomposition. No fumes arise from it. A piece of polished zinc suspended above it in a closed bottle remains untarnished for many months. It has a strong affinity for water, and if 4 parts of it are added to one of water at the freezing point, the temperature of the mixture speedily rises to 212°.

Commercial oil of vitriol is tolerably pure. The principal impurity is sulphate of lead, which is detected by its producing a white turbidity when the acid is diluted with distilled water.

Nordhausen oil of vitriol is a dark coloured fuming sulphuric acid, composed of a mixture of anhydrous and hydrated sulphuric acid. It is manufactured in Germany.

Anhydrous sulphuric acid is a tenacious crystalline mass, which in the absence of all moisture has no acid properties. When water is added to it, combination takes place, with heat, light and explosion.

Sulphuric Ether. *See* "Ether."

Sulphurous Acid. $SO_2$. This acid is produced by the combustion of sulphur in oxygen. At ordinary temperatures it exists as a gas, but at the freezing point becomes liquid. At a lower temperature it may be solidified, and then forms a white mass. Water which has been recently boiled absorbs about 30 volumes of it. The solution possesses bleaching and deoxidizing properties.

Sumach. A yellow dye, and tanning material, extracted from the dried and bruised branches of certain species of Rhus cultivated in Italy and the South of France.

Tangent. The tangent to a curve at any point P is defined thus: Take any other point Q, and draw a straight line through P, Q. This straight line cuts the curve in the points P, Q, and is called a "secant." Now let the point Q move along the curve towards P. When it has approached to within a distance less than any assignable distance from P, but without actually coinciding with P, the secant PQ becomes a tangent to the curve at P.

This definition applies equally, either to the case of a curve of double curvature (like a corkscrew), or to a curve which lies upon a plane.

The Tangent-Plane to a surface at a point P is found by cutting the surface by any two planes which pass through P, finding the tangent lines through P to each of the plane curves thus produced, and drawing a plane through those two tangent lines.

If two points, Q, R, be taken on the surface, and a plane PQR drawn through them, and we suppose Q, R, to move towards P, then the plane PQR, when Q and R have approached P to within a distance less than any assignable distance, is *not* necessarily the tangent plane at the point P, as it is sometimes stated to be in books of geometry.

Tannin; Tannic Acid. $Tn. = C_{18}H_5O_9 + 3HO$. An astringent principle contained in various vegetable substances, but principally in infusion of galls. It is obtained in a pure form by treating powdered galls with washed ether, *i.e.*, ether containing 10 per cent. of water; this is allowed to filter through the galls, and the filtered liquid divides itself into two strata, the upper one being ether, and the lower a concentrated aqueous solution of tannic acid. This is evaporated in vacuo over sulphuric acid, and pure tannin remains as a bulky pale-yellow residue, which is exceedingly soluble in water, but less soluble in absolute ether and alcohol.

The aqueous solution of tannic acid reddens litmus paper, and exhibits the properties of an acid, displacing carbonic acid from the carbonated alkalis with effervescence, and forming salts called tannates.

Tannin combines energetically with gelatine, and forms an insoluble precipitate when added to solutions of isinglass, or glue. When oxidized, tannin becomes converted into gallic and carbonic acids. Its chief use in photography consists in producing a leather varnish upon paper positives (*q.v.*).

A concentrated solution of tannin is precipitated by nitric and hydrochloric acids, but not by oxalic, tartaric, lactic, acetic, or citric acids. Tannin, when added in excess, gives a dark blue or black colour to solutions of the *per*salts of iron, but produces no immediate change in solution of the pure *proto*salts. The black precipitate produced in the former case is common writing ink, and is composed of one atom of peroxide of iron and three atoms of tannic acid.

TARTAR. BITARTRATE OF POTASS. A white salt nearly insoluble in cold water, and quite insoluble in a cold mixture of alcohol and water. It has an acid reaction. It exists abundantly in the juice of the grape, and is deposited in wine casks in the form of an incrustation called "argol," which is purified and whitened by solution in boiling water, and crystallization.

Neutral tartrate of potass is produced by neutralizing a solution of bitartrate of potass with lime.

TARTARIC ACID. Tar.$=C_8\,H_4\,O_{10}+HO$. This acid exists free in many acid fruits and plants, and is generally obtained from cream of tartar, in the form of white crystals, which are soluble in about 4 parts of water at 60°, and also in alcohol. It is a very powerful organic acid in photography, and should be used with caution. It is deliquescent in damp air.

Paper washed with a solution of tartaric acid is said to be slightly sensitive to light.

TARTRATE OF SILVER. This salt is produced by adding tartrate of potass to solution of nitrate of silver; the white precipitate thrown down being tartrate of silver. It is darkened and decomposed both by heat and light.

**Taupenot's Process.** This is a dry preservative process in which a glass plate is first collodionized and excited, then coated with iodized albumen, and excited a second time. Three years ago, before the problem of dry collodion was solved, this process, discovered by Dr. Taupenot, Professor of Chemistry at a French college, was brought forward and excited so much attention that it has not even yet been completely abandoned by amateur photographers for the better process of Dr. Hill Norris, of Birmingham, since discovered and perfected.

The operations are as follow:—

A plate is first collodionized and excited in the usual way. It is then washed with distilled water for the purpose of removing the free nitrate of silver. A mixture containing about equal parts of albumen and water, and 1½ per cent. of iodide of potassium, is then poured over it. This completely destroys the sensitiveness of the plate, which may then be dried in daylight before a fire. It is now ready to be excited a second time. This is effected by immersing it in a bath of aceto-nitrate of silver, containing 50 grains of nitrate of silver and 1 dram of acetic acid. The plate is then washed with distilled water, and either dried by artificial heat, or allowed to dry spontaneously. It is now ready to be exposed in the camera, and may be kept for several days, or perhaps weeks, in a sensitive state.

The picture is developed by first steeping the plate in a dish of distilled water for a minute or two, then laying it upon a levelling stand, and pouring over it a saturated solution of gallic acid to which a few drops of aceto-nitrate of silver are added. It is fixed in the usual way with hyposulphite of soda, *not cyanide of potassium;* for the latter salt should never be used with albumen films, as it acts too energetically upon albumen.

The pictures obtained by this process have a yellowish or greenish tint, and are not therefore suited for transparencies.

The collodion should be porous and adhesive, and not hard and contractile, or blisters will be produced when the film is wetted a second time.

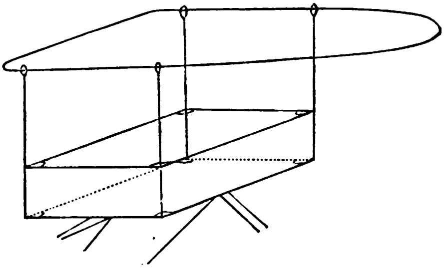
The objections to the process are,—the multiplicity of operations,—the bad colour of the pictures,—and the discoloration of the second nitrate bath. As a set off to these objections it has no advantage whatever over dry collodion.

The plates may be developed more quickly with pyrogallo-nitrate of silver, but the definition is not quite so good, and stains more liable to occur.

**Tent.** When views are taken by the wet collodion process, in which the free nitrate of silver is not removed from the plate by washing, it becomes necessary to operate either in a dark room, or van, or tent, at or near the spot whence the view is taken; for otherwise the latent image is destroyed by the evaporation of the moisture from the sensitive plate, and the consequent solution of the iodide of silver by the concentrated nitrate in the film.

The dark tent used by travelling photographers is of various forms and sizes, and more or less portable. For large pictures 12 × 10, or so, perhaps the best form is that of the ordinary military tent, having a pole at each end and fastened to the ground with ropes and pegs. It should be made with black calico, lined with yellow. In one of the gable ends there should be a yellow window, and the entrance should be in the opposite gable. Inside there may be a table and all the necessary conveniences. This kind of tent has of course no pretensions to portability, and a travelling van is preferable, since much time is necessarily occupied in erecting and taking down a tent of this form.

For stereoscopic pictures, or pictures not exceeding 8 × 6, a much simpler and more portable form of tent will answer the purpose. A deal tray about 2ft. 6in. long, 1ft. 9in. wide, and 4 ins. deep, is screwed upon a short tripod stand. At the corners the four uprights of a light iron frame are inserted, which is made thus;—



the rods being about the thickness of stair rods.

A covering made of black calico lined with yellow is thrown over this frame, and hangs down to the knees. In this covering at the back is a yellow window nearly the whole height of the iron rods and about 6 inches wide; the yellow curtain of this window or aperture may be drawn backwards and forwards at pleasure. The tray has a shelf at the back which carries the bottles, etc.

To use this tent the operator stands beneath the projecting part of the top of it, with the tray in front of him, and draws the lower part of the curtains tightly round him under his elbows, and fastens them by means of hooks to the inside of the front part of the tray so as to exclude day-light. He has then his hands at liberty, and manipulates in the usual way. By putting a tent of this kind, together with the chemicals and apparatus, upon a wheelbarrow, or suitable truck, or basket with wheels which ship and unship, the photographic tourist becomes independent of help from others.

TEST PAPERS. Make an infusion of commercial litmus, and steep blotting paper in it; dry it, and cut it into narrow strips. It is of a deep indigo colour, and is reddened by being immersed in any acid solution, or exposed to acid fumes. This blue litmus paper, as it is called, is therefore a test for acidity. It may also be used as a test for alkalies by dipping it into very dilute sulphuric acid, and drying it. In this state it is called reddened litmus paper, and its original blue colour is restored by immersion in any alkaline solution. A volatile acid, such as acetic, should not be used in making reddened litmus paper. Another kind of test-paper for testing alkalinity is made by steeping blotting paper in an infusion of turmeric; this is of a yellow colour, which is changed to brown by the action of an alkali. It is not considered so good as reddened litmus. But the best kind of test paper for testing alkalinity is made by steeping blotting paper in a strong infusion of the petals of the red rose. The red colour of this kind of paper is changed to green by an alkali.

When a solution to be tested is very *feebly* acid or alkaline a few minutes must be allowed before the change of colour in the test-paper is perceived.

Test-papers, as usually sold by chemists, are made up in little long narrow books. They are indispensable to the photographer for testing the condition of the nitrate bath.

THERMOMETER. (Gr. ϑερμη heat, μετρον a measure.) This is an instrument for measuring temperature by recording the expansion produced in a liquid by heat.

The mercurial thermometer consists of a glass tube of fine and *equal* bore, having a bulb at one end. This tube is filled with mercury at a high temperature, above boiling point, and its end hermetically sealed. On cooling, the mercury contracts and leaves what is called a Torricellian vacuum above it in the tube, *i. e.* a space filled with the vapour of mercury.

To graduate the thermometer, it is first immersed in melting snow, the temperature of which is found to be invariable, and the height of the mercury marked; and next in water boiling in a thin polished metallic vessel at a barometric pressure of 30 inches, a temperature which is also found to be invariable, and the height of the mercury marked again. These two graduations are called the freezing and boiling points of water. The space between them is divided differently in different thermometers, as shown in the table at the end.

The thermometer used for testing the temperature of liquids is furnished with a hinged back, so that the bulb and lower part of the tube only can be inserted in the liquid.

If equal parts of hot and cold water are mixed together the thermometer indicates accurately the arithmetical mean between the temperatures.

TINCTURE OF IODINE. This is composed of 48 grains of iodine added to one fluid oz. of alcohol S. G. 835. The iodine is dissolved and the tincture poured off into a well stoppered bottle.

TONING-BATH. In printing positives by direct light, the purple tint due to the subchloride of silver is removed by the fixing agent, and nothing remains but a red compound of silver and organic matter. In order therefore to render a sun-print presentable as a work of art the thin red tint of the shadows must be blackened or intensified by some means. This is effected by the toning bath, which either darkens the print by sulphurating the silver in the image, or substitutes gold for silver, according to its composition. Developed prints do not necessarily require a toning bath, since the material of the image is sufficiently black and intense without it. The most suitable toning-bath to be employed in the various printing processes is described in the articles which treat of those processes.

TOURNESOL. The French term for Litmus, *q. v.*

TRACING-PAPER. There are two kinds of tracing paper, viz., transparent, and black. Transparent tracing-paper is made by smearing the paper with boiled oil, or magilp, or colourless dammar resin dissolved in turpentine or benzole; or better still, with Canada balsam diluted with turpentine. Black tracing-paper is made by saturating a piece of blotting paper with a mixture of lamp-black ground in honey; or by rubbing a piece of sized paper with black-lead or black chalk. The tracing is first made upon the transparent paper in lead pencil, this is then laid upon the black paper, and that with its blackened side upon the paper which is to receive the final drawing. The lines on the tracing-paper are then gone over with a porcupine's quill, or other hard point, exerting a gentle pressure. A corresponding outline is thus obtained upon the paper beneath the black one. Sometimes blue paper is used instead of black; this is made by substituting indigo or prussian blue for lampblack.

The transparent paper made with Canada balsam takes ink and water colours freely. A tracing-paper is made in France from raw flax, and is called "Papier Végétale."

TRANSFERRING. A collodion picture which is not too porous and powdery may be transferred from the glass plate, when wet after the final washing, in the following manner:—

Lay a thick and wet piece of blotting paper upon the film in such a way as to cover the plate all but about a quarter of an inch at one end. Turn the narrow edging of film which is outside the blotting-paper over it by means of a penknife, and then, beginning at that end, raise the blotting-paper gently off the plate; the film will come off with it. It may be permanently fixed to a sheet of dry gelatinized paper, by laying the blotting-paper bearing the film upon the gelatinized paper, pressing the two into close contact, and letting them dry spontaneously, when the blotting-paper will come off, leaving the film attached to the gelatinized paper so strongly as to resist all attempts to remove it again by scratching or rubbing. The paper may then be waxed.

Collodion positives may be transferred from glass to glazed leather by damping both the film and the leather with alcohol, pressing the two into contact, and in a few minutes peeling off the leather, which brings the film with it, apparently so incorporated with the black glaze as to be incapable of being removed by scratching with the nail, &c.

Collodion negatives may be transferred to gutta-percha in the following manner described by M. Leon Cassagne at a meeting of the French Photographic Society on June 19, 1857.

"It is generally known that at the Imperial Printing Office of Vienna, when a good collodion negative has been obtained on glass, it is the custom to transfer it by means of a double film of gelatine, and gutta-percha dissolved in chloroform. The process which I have adopted, and which has never been described in the Bulletin of the Society, consists in first dissolving—

| | |
|---|---|
| Pure gutta-percha . . . | 1·92 grammes |
| Chloroform, or Benzole . . | 31·09 „ |
| or, | |
| Gutta-percha . . . | 2·56 grammes |
| Chloroform, or Benzole . . | 31·10 „ |

"You perceive that the quantities are not invariable. There are cases in which it is necessary to vary them. I shall not enter into details; the operator, in each particular case, will be able to decide for himself.

"When the negative on the glass is dry and in good condition, pour on the collodion side a coating of the above solution. Let it run slowly and uniformly, that it may have time to penetrate and unite with the collodion film. As soon as this coating is completely dry, strengthen it with a second, formed of the following substances:—

| | |
|---|---|
| Gelatine of commerce, (very white) . | 30 grammes. |
| Filtered water, as much as the gelatine can absorb, until it has swelled to the utmost. | |
| Isinglass . . . . . | 5 ,, |
| Alcohol . . . . . | 15 ,, |

"Melt the gelatine in the water which it has absorbed, by placing the vessel containing it in hot water. Melt the isinglass in the same way in the alcohol. Mix by degrees, and with care; stirring with a wooden spatula this species of varnish. Warm it with precaution, that it may not be injured by too much heat. Hold the negative, the coating of gutta-percha upwards, before a clear fire, or over a spirit-lamp, until it is heated to 10 or 20° centigrade; then pour over it immediately (removing it from the flame of the lamp), a coating of gelatine, as thin as its density will allow. It is unnecessary to say that the gelatine must be warm and perfectly liquid at the time. Leave it for an instant to cool and dry, sheltered from dust, and you will be able to remove easily, by means of the steam from boiling water, the triple film of collodion, gutta-percha, and gelatine. This operation, which is very easy, is performed as soon as you see that the film is slightly softened by the steam, and you should then begin to remove it from the glass at the corner from which the excess of collodion was poured off when the plate was collodionized. It often happens that the film disengages itself at this corner of the glass. It is a good plan to facilitate the entire removal of the film with a thin blade of flexible polished horn, on which, with the help of fingers, you support the film, while you detach it by degrees, either with, or without, the aid of a thin thread of water, running drop by drop from a tap, and which insinuates itself by degrees under the collodion, between it and the glass. As soon as the entire film is raised, flatten it between two pieces of glass, having good surfaces, and sufficiently thick to act by their own weight. The collodion used must have *sufficient* consistency, not so much however as to leave striæ or lines on the plate when dry.

"The chloroform or benzole solution, should be allowed to stand several days before being used, in order that the colouring matter, or any impurities in it, may be deposited. Filter through paper, that the solution may be sufficiently thin, shutting the top of the funnel to prevent too much evaporation, which would have the effect of thickening the solution. Benzole, of specific gravity much less than the chloroform, gives good results, but inferior to those obtained by chloroform, which gives a solution almost colourless, and adheres firmly when the evaporation is completed; which also takes place more rapidly than with the benzole.

"The density of the solution of gutta-percha, which is always slightly coloured, retards considerably its complete clarification. It is necessary to avoid all impurities in this solution."

The following is a method of transferring dry collodion negatives to paper, described by M. Bayard at a meeting of the French Photographic Society on Feb. 20th, 1857.

"Among the specimens which I have the honour to lay before you are some which have been obtained from very old negatives, and even from negatives which have been varnished. They have all been easily transferred. I cannot however promise you that it will always be so. It is probable that certain varnishes, and particularly fatty varnishes, may offer an impediment to the softening and removal of the collodion film.

"I am afraid also that albumen and gelatine spread upon the negatives may interfere with the success of the operation; and I must warn you that I have not yet succeeded in transferring with certainty negatives produced by Taupenot's process, either simple or modified.

"The following is my process:—

"In order to detach the film of collodion from the glass, I use paper coated with gelatine.

"To prepare it, dissolve in one *litre* of filtered rain water, 40 *grammes* (about 4 per cent.) of colourless gelatine. When the gelatine is dissolved, pour the solution into a dish which has been previously heated. Float the papers on the bath for one or two minutes, and hang them up by a corner to dry. When dry, keep them in a portfolio until required for use. The kind of paper which appears most suitable for this operation is Canson's thin negative paper.

"If the negative to be transferred has just been taken, and is still wet, place the glass on a horizontal support, collodion side upwards, and cover it equally and evenly with water. Then, take a sheet of the prepared paper, (which should be of the same size as the glass,) float the gelatinized side for three or four minutes on a bath of water, and having carefully removed it, lay it on the water with which the glass has been covered. Then, by inclining the glass, allow the water to drain off and the paper to become attached to the collodion. Place the glass perpendicularly, and allow it to dry spontaneously.

"When the negative which you wish to transfer is old, and has not been varnished, immerse it for about a quarter of an hour, film upwards, in a dish full of water. Ten or twelve minutes after putting it into water, lay a sheet of gelatinized paper on the same water for three or four minutes. Then, remove the glass by the corners in such a way as to remove with it the paper which floats above, (the edges being of course properly adjusted to those of the glass). By proceeding cautiously the paper will adhere to the collodion. Drain and dry as before.

"When the negative has been varnished, proceed as before, with this difference, viz.:—add 3 or 4 per cent. of alcohol to the water, and let the glass remain in it half an hour.

"When the paper which has been glued to the collodion has become perfectly dry, (it should not be dried by the fire,) make an incision with the point of a penknife all round it, pretty close to the edges of the glass, and then immerse the negative in a dish filled to about an inch deep with water. A quarter of an hour after, you may endeavour to raise a corner of the negative film with the point of a knife. Should the film not come off with the paper, leave it immersed a little time longer. As soon as you find that the collodion will leave the glass, raise the paper carefully, without removing the glass from the water, which always moistening the collodion renders the operation more easy. When the paper has been removed with the collodion film adhering to it, press it between blotting paper, and dry it.

"Negatives transferred in this way acquire great vigour for printing, and if the prints from them are found to be too strong in the contrasts, the negative should be waxed on the reverse side of the paper in the ordinary way."

After M. Bayard had made the above communication, he, in order to shew with what ease these transfers could be made, placed in water a collodion negative on glass, having a sheet of gelatinized paper adhering to the film.

M. Le Gray, who had lent this negative, said that he had warned M. Bayard that it was in very bad condition for transferring, as the film wanted consistency; but that if the experiment succeeded it would be the more conclusive. Notwithstanding these unfavourable conditions M. Bayard effected the transfer with complete success.

Collodion positives may be transferred to paper by the following process, communicated about a year ago to the "Photographic Notes" by Mr. Manson, of Edinburgh.

"To make the transfer varnish:—take of borax 1 dram, shellac 4 drams; digest them in about 5 ounces of water, nearly boiling, in a covered vessel, till the whole is dissolved. When cold it is ready for use.

"To transfer the film:—Apply a coat of the varnish to the surface of the picture with a large and soft camel's hair brush, and dry it quickly by holding it over a flame, or at a fire. When cold, applying a second coating of varnish, as before.

"Then take a piece of black paper a little larger than the glass. Coat it, and also the picture, with varnish, and lay the two wet surfaces together, beginning at one end, and carefully excluding every bubble of air. When nearly dry lift one end, and strip the whole from the glass. It is now ready for mounting."

Daguerreotypes may be transferred to paper by the following process described by Mr. Belfield Lefevre, of Exeter, in the Photographic Notes, Vol. 2, page 343.

"To obtain a negative by transferring to the surface of some more or less transparent substance the loose particles which form the lights and half-tints of Daguerre's image, is an idea which must have suggested itself to the minds of many, whilst the means by which this transfer may be effected are as simple as the idea itself is obvious; and yet, although from the day on which M. Arago communicated M. Daguerre's process to the Academy of Sciences, I have been a votary of the Photographic art, and am not unfamiliar with Photographic literature, I have seen no allusion, however remote, to any such process. Is it that the results so obtained have not been found available for the purposes of photographic printing? However this may be, as it is not in my power to pursue these researches any further, I submit the process to your judgment in its present imperfect state, and my sincere desire to contribute to the progress of photography must be my excuse. The following then is a short, but I believe sufficient description, of the *modus operandi.* I purposely omit mentioning those precautions which are familiar to all careful operators.

"1st.—Dissolve one part of pure gelatine, and one part of clarified uncrystallizable sugar (golden syrup of the grocers), in ten parts of boiling water, and pour out the hot solution in a shallow pan.

"2nd.—Float for a few minutes on the hot solution a sheet of Hollingworth's thin negative paper, previously well dried,

"3rd.—Draw off the paper, holding it vertically, at a short distance from the fire, until the superabundant liquid has ceased to drain off,

"4th.—Lay it out horizontally on a cold slab, until the gelatine has firmly set.

"5th.—Meanwhile take the image to be transferred fresh from the mercury box, and having washed it first in the solution of hyposulphite, and then in water, put it on end to drain, until the formation of the horizontal water line marks that the liquid on the surface is reduced to a mere film.

"6th.—Lay the gelatine paper on the image, pressing it down firmly and evenly with a soft cloth, until it is brought at every point in perfect contact with the surface of the metal.

"7th.—After a few minutes peel off the paper. Some caution will be required, as it will be found to adhere rather firmly.

"If the proof has been well selected, and the manipulation successful, every particle of reduced silver will be found transferred to the surface of the gelatine, and a faint vestige of the original image will alone be traced on the black and polished surface of the silver.

"I say, if the proof has been well selected, for this is a point of much importance. Of course the choice would fall on a full-bodied proof, with thick and creamy lights, and rich opaque middle tints, but this alone will not be found a sufficient guide, and it will be advisable to pass a camel's hair brush gently over some portion of the washed image; if the passing brush leaves a tract of black and burnished metal behind, the transfer may be attempted, if not the operation will not be successful.

"On examining the transferred image by reflected light, it will appear as a faint and somewhat shadowy transcript of the original drawing, in which a careful inspection in a favourable light will detect many details re-produced with great sharpness and delicacy. By transmitted light, however, the semi-transparent nature of metallic films of extreme tenuity will be found painfully evident. It is indeed a faint negative, but it differs from those obtained by ordinary processes in two most important particulars. In the first place its lights are perfectly and absolutely pure, and in the second its half-tints, however faint, are all represented by a metallic equivalent, really and substantially existing on the surface of the gelatine, and which, therefore, may become the basis of a chemical action, although too minute to be detected by the most careful inspection. The colour of the metallic film varies greatly, generally approaching to a reddish brown where it is most dense. This clearly points out a fact for which we should hardly have been prepared, viz., that the high lights in Daguerre's image are in reality formed of two distinct layers, the upper stratum being blanched by the action of the mercury, and probably amalgamated with it, whilst the lower retains the reddish hue which reduced silver sometimes assumes. The rosy tint which is observable in the high lights of the finest proofs, when seen obliquely, is thus explained. Considered as a basis of chemical action, the transferred image is a sheet of gelatine, on which particles of pure metallic silver, or of silver amalgam, are more or less densely strewn. To increase the opacity of these particles, so as to render them less permeable to the rays of transmitted light, is the problem still to be solved, and for the solution of which three methods are open:—First, to transform the metallic particles into some binary compound, such as an oxide, a sulphuret, an iodide, or a chloride; secondly, to substitute for them thin chemical equivalents of platinum or gold; and thirdly, to render them the centre of a catalytic action, which shall group around them fresh molecules of reduced silver. The very few experiments which I have been able to make in these different directions have impressed me with the belief that no very serious obstacle is to be apprehended. Thus I have found that the action of iodine transforms the metallic film into a saffron-coloured compound which is not altered by exposure to light. Bi-chloride of mercury changes it into a greyish powder, which is again darkened by a weak solution of ammonia, and the terchloride of gold increases considerably the intensity of the image, but forms unfortunately, with the gelatine, a compound of a truly Tyrean purple tint.

"All these, however, are topics on which I need not dwell, as they will naturally suggest themselves to the minds of those who may deem the subject worthy of investigation."

TRAGACANTH. *See* "Gum Tragacanth."

TRANSPARENT CEMENT. Dissolve 75 parts of caoutchouc in 60 parts of chloroform, and add 15 parts of mastic.

TREACLE. The uncrystallizable sugar or syrup obtained from the sugar cane. Golden syrup is a thin light-coloured treacle, better adapted for photographic purposes than common treacle.

TRIPOLI. The waxen veins, or *Septoriæ ludi Helmonti*, found on the east coast of England, calcined; also the curl-stone of the Staffordshire mines, calcined. It contains 80 per cent. of silica, and is used for cleaning and polishing metals, &c.

TURMERIC. The root of an Indian plant, the *Curcuma longa*. The powder is orange yellow, and the tincture used for making test-papers, (*q. v.*). The colouring matter of turmeric is called "curcumine."

TURPENTINE. Crude turpentine is a kind of balsam composed of a resin and a volatile oil, and obtained as an exudation from the wounded bark of various trees, but particularly the fir. It is imported chiefly from America.

Oil of turpentine is obtained by distilling crude turpentine with water; the residue left in the still is common resin, and the volatile oil passes over with the steam, with which it mixes. It is a limpid, colourless liquid, S. G. ·86, and boiling point 314°. It is neutral to test paper, and almost insoluble in water, but is taken up to a greater extent by absolute alcohol and ether. It mixes readily with oils, and is very inflammable, depositing a dense soot, which is lamp black, or carbon in a finely divided state. Its composition is $C_{10} H_8$. It is a solvent of the resins, and to some extent of caoutchouc.

Oil of turpentine is acted on energetically by sulphuric and nitric acids, and chlorine; with hydrochloric acid it forms a curious compound, called artificial camphor. It combines with iodine and bromine.

ULTRAMARINE. A magnificent blue pigment obtained from a rare mineral, called "Lapis lazuli."

ULTRAMARINE, ARTIFICIAL. This substance, which is chiefly composed of sulphide of sodium, is extensively used in the arts, particularly by paper makers for giving a blue tint to paper. There is a very large manufactory of it at Dusseldorf, where some hundreds of men and women are employed. The following is the account of the process, as described by Dr. Redwood.

"Mix together 1 part of porcelain clay, 1½ part of sulphur, 1 part of anhydrous carbonate of soda, and keep the mixture at a dull red heat in a covered crucible as long as vapours are given off. On opening the crucible it will be found to contain a spongy mass part of which will be of a dark-blue colour, and this is to be separated from the other part. The results of this process are not uniform, yet it is considered the best that has yet been published."

Since photographic prints are readily destroyed by an alkaline sulphide, it is evident that the above colouring matter should on no account be added to photographic papers, and yet all the foreign papers manufactured for photography are tinted with it.

**Uranium.** $U=60$. This metal is obtained from the mineral termed Pechblende, which is an impure oxide of it, and also from uranitic mica. The process consists in acting on the oxide with potassium. It is obtained as a black powder which has a powerful affinity for oxygen. The protoxide of uranium was for some time mistaken for the metal itself, and is not by any means a costly substance.

There are five oxides of uranium, viz.:—

| | |
|---|---|
| Suboxide | $U_4 O_3$ |
| Protoxide | $U O$ |
| Black oxide | $U_4 O_5$ |
| Green oxide | $U_3 O_4$ |
| Peroxide<br>Sesquioxide<br>Uranic acid | $U_2 O_3$ |

The protoxide is a grey or brown powder obtained by passing hydrogen over peroxalate of uranium at a red heat. The salts of the peroxide are reduced to salts of the protoxide by the action of light, as in the case of the iron persalts, so that in this respect uranium and iron are analogous. The hydrated peroxide is a yellow powder.

**Uranium Glass.** Glass is frequently coloured yellow by the addition of oxide of uranium. It possesses the property of "Fluorescence," *q. v.*

**Uranium-Printing Process.** A sheet of paper is first rendered sensitive to light by immersing it in a strong solution of a salt of the peroxide of uranium, (the nitrate is probably the best). It is then dried, and exposed under a negative to direct light for about the same time as an ordinary sun-print upon a chloride of silver paper. A very faint visible image is thus obtained, which is perceived by holding the paper against the light. The print is then placed either in a weak solution of chloride of gold, or in a strong solution of aceto-nitrate of silver. In the former case a picture is obtained of a purple inky tint, and in the latter case of a chocolate brown tint. The print is then washed in abundance of water, several times renewed, and the operation is complete.

The theory of the process appears to be as follows:—

The uranium persalt is reduced by light to a protosalt, which, when the print is placed in the gold or silver developer, becomes again oxidized, and the gold or silver reduced, either to a purple substance in the case of gold, or a brown substance in the case of silver. The redundant chemicals are then removed by washing, no fixing agent being necessary.

The principal objection to this process appears to be the difficulty of obtaining good surface vigour, and fine definition; there is also the fear of the lights becoming discoloured in consequence of the imperfect removal of the chemicals from the paper. Since no hyposulphite of soda is employed in fixing, the prints may be considered much more permanent than ordinary sun-prints that have been fixed and toned by hypo and gold.

Uranium prints developed with silver may be intensified by immersing them in a solution of protosulphate of iron acidified with acetic acid; but the lights of the picture are very liable to become discoloured if no fixing agent, such as hypo or cyanide, be employed.

The uranium printing process is identical in principle with the Chrysotype process of Sir John Herschel, published in 1842; *q. v.*

VARNISHES. An excellent practical account of the manufacture of varnishes, by Mr. J. W. Neil, will be found in the 49th volume of the Transactions of the Society of Arts. But the photographer is not so much concerned with knowing the particulars of this manufacture in its various branches, as with knowing the best formulæ for making the two or three different kinds of varnish which are used in photography. These are as follow:—

*Benzole Varnish.* This may be applied to glass plates without the application of heat, and it dries very quickly, leaving a tolerably hard film, which does not become sticky at ordinary temperatures. It is made by adding finely pulverized gum dammar to pure benzole. The dammar readily dissolves, and the varnish may then be filtered through cotton wool to separate any solid particles there may be in it. The proportions are about one ounce of dammar to a pint of benzole. The varnish is applied to the plate exactly in the same way as collodion.

Instead of dammar finely powdered amber may be employed, and this varnish will be found better than amber dissolved in chloroform, though probably not so good and more costly than that made with dammar.

*Spirit Varnish.* This is the best varnish for photographs upon glass, but there is some little trouble and risk in applying it. It is made thus:—

Put into a glass flask

| | |
|---|---|
| Alcohol S. G. ·825 | 20 fluid ounces. |
| Pulverized white lac | 1½ ounce. |
| Sandarach | 1½ drachm. |

Put the flask into hot water, having previously wrapped a piece of paper loosely over the mouth of it. The ingredients are soon dissolved, and may then be filtered by passing the varnish through cotton wool.

Instead of white lac, seed-lac may be employed, but the varnish is then of a darker colour. Methylated spirits may be used as the solvent. French polish diluted with an equal part of alcohol makes a good spirit varnish for negatives.

Before applying the varnish the plate must be dried and heated before the fire to a temperature of about 100°; not more, or there will be a risk of destroying the picture by causing it to run in smears down the glass when the superfluous varnish is poured off the plate into the bottle. On the other hand, if the plate be not heated sufficiently, the varnish will be chilled, and produce the effect of ground glass. The plate must be warmed again while the varnish is drying. When spirit varnish is properly applied it forms an exceedingly hard and tough film, which it is difficult to scratch or injure during the process of printing, and which does not become sticky by heat.

Spirit varnish must never be applied a second time to a plate. If this be attempted the picture will most probably be spoiled.

*Black Varnish.* This is made by dissolving in one bottle powdered asphaltum in benzole, and in another, india-rubber in benzole; then adding the latter to the former in such proportion as may seem best, the object of the india-rubber being to prevent the black varnish from cracking.

The india-rubber should be cut into small pieces, and left two or three days to dissolve in the benzole, which it does without heat.

Varnishes may be divided into two classes,—viz. fat varnishes, and spirit varnishes; and the latter class may be subdivided into two, in one of which alcohol is the solvent, and in the other turpentine.

The principal fat varnish used by painters is copal, and the principal spirit varnish mastic, but neither of these is suitable for photographic purposes. Varnish for maps and drawings may be made by adding turpentine to canada balsam in about equal parts, and gently heating the mixture. The paper should be sized with gelatine before applying the varnish. Another paper varnish may be made by digesting together—amber 300 parts, camphor 1 part, alcohol 1500 parts. White lac dissolved in borax may also be used as a paper varnish. Another kind of paper varnish may be made from Xyloidine; (*q. v.*). Paper may be varnished by floating it upon albumen, drying it, and then coagulating the albumen by floating the back of the paper upon boiling water. *See* also "Leather Varnish."

VINEGAR. *See* "Acetic Acid."

VISION. (Latin, *videre* to see.) The phenomena of human vision will be described under two heads, viz. monocular vision, and binocular vision.

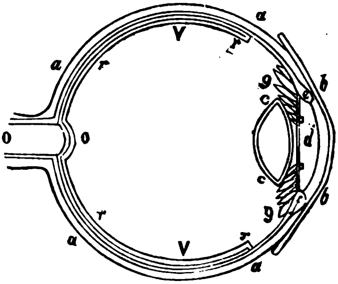
### *Monocular Vision.*

Vision is said to be "monocular" when only one eye is employed.

The human eye may be considered as a sort of spherical camera obscura, in which the pupil, (or little black dot in the centre of the eye), is the diaphragm, and the retina the focussing screen; this admirable natural camera being then placed within a socket lined with fat, in which it works by means of voluntary muscles that are attached to it, and by which its axis is directed towards any point with astonishing rapidity and precision.

The following account of the human eye is so excellent, that we extract it verbatim from a Treatise on Optics published by the Society for the Diffusion of Useful Knowledge.

"The human eye, of which a vertical section is given in the following figure, is nearly of a globular form, with a slight elongation or projection in front. It consists of *four* coats or membranes, viz. the *Sclerotic*, the *Cornea*, the *Choroid*, and the *Retina*; of two fluids or humours, the *Aqueous* and the *Vitreous*; and of one lens, called the *Crystalline*. The Sclerotic coat, *a a a*, is the outer and strongest coat, to which the muscles for giving it motion are attached. It constitutes the white of the eye. It is joined to the *Cornea*, *b b*, or the clear and transparent circular



membrane through which we see. The *cornea*, which is equally thick throughout, is very tough, and consists of several layers or folds to give it strength, so as to defend the delicate parts within from external injury. On the inner surface of the sclerotic coat is a delicate membrane, called the *Choroid* coat, which is covered with a black pigment. On the inner side of this lies the *Retina*, *rrrr*, which is the innermost coat, and is a tender reticular membrane, formed from the expansion of the optic nerve, which enters the eye at O, a little more than *one-tenth* of an inch from the axis on the side towards the nose. At the end of the axis of the eye, and in the very centre of the retina, there is a small hole, with a yellow margin. It is called the *foramen centrale*, or central hole, though it is not a hole but merely a transparent spot, free of the soft pulpy matter of which the retina consists.

"A flat membrane of a circular form, *e f*, called the iris, and seen through the cornea *b b*, divides the interior globe of the eye into two very unequal parts. It has a circular opening, in its centre, called the *pupil*, which *expands* when the light which enters the eye is *diminished*, and *contracts* when the light is *increased*. The space before the *iris*, called the *anterior chamber* of the eye, contains the *aqueous humour*, from its resemblance to pure water; and the space behind the iris is called the *posterior chamber*, and contains the *crystalline lens*, *c c*, and the *vitreous humour*, which fills all the rest of the eye. The *crystalline lens* is suspended in a transparent *capsule*, or *bag*, by what are called the *ciliary processes*, *g g*. This lens is more convex behind than in front, as the figure shows; and it consists of concentric coats composed of fibres. It increases in density from its circumference to its centre, for the purpose of correcting its spherical aberration. The *vitreous humour*, V V, occupying the largest portion of the eye, lies immediately behind the *crystalline lens*, and fills the whole space between it and the retina, *r r r r*.

"The following are the dimensions of the eye, as given by Dr. Young and M. Petit:—

| | English inches. |
|---|---|
| Length of the optical axes | 0·91 |
| Vertical chord of the cornea | 0·45 |
| Versed sine of ditto | 0·11 |
| Horizontal chord of the cornea | 0·47 |
| Opening of pupil seen through the cornea | 0·27 to 0·13 |
| Diminished by magnifying power of cornea to | 0·25 to 0·12 |
| Radius of the anterior surface of the crystalline lens | 0·30 |
| Radius of the posterior surface | 0·22 |
| Principal focal distance of the lens | 1·73 |
| Distance of the centre of the optic nerve from the central hole at the end of the axis | 0·11 |
| Distance of the iris from the cornea | 0·10 |
| Distance of the iris from the anterior surface of the crystalline | 0·92 |
| Range of the eye, or diameter of field of vision | 110° |

"Dr. Brewster and Dr. Gordon took the following measures of the crystalline and cornea from the eye of a woman above fifty years of age, a few hours after death.

| | |
|---|---|
| Diameter of the crystalline | 0·378 |
| Diameter of the cornea | 0·400 |
| Thickness of the crystalline | 0·172 |
| Thickness of the cornea | 0·042 |

"The following are the refractive powers of the humours of the eye, according to different observers:—

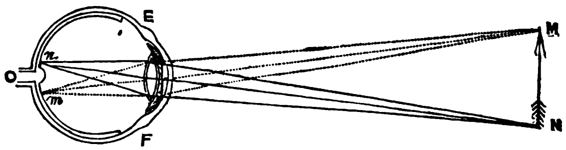
| | Aqueous Humour. | Crystalline Lens | | | Vitreous Humour |
|---|---|---|---|---|---|
| | | Outer Coat | Centre | Mean | |
| Hauksbee | 1·33595 | ........................................ | | | 1·33595 |
| Jurin | 1·3333 | | | | |
| Rochon | 1·329 | ........................................ | | | 1·332 |
| Young | 1·3333 | | | | |
| Brewster | 1·3366 | 1·3767 | 1·3990 | 1·3839 | 1·3394 |

"From the last of these measures we may deduce the following indices of refraction:—

| | Index of Refraction. |
|---|---|
| For rays passing from the aqueous humour into the outer coat of the crystalline lens | 1·0466 |
| For rays passing from the aqueous humour into the crystalline, taking its mean index of refraction | 1·0353 |
| For rays passing from the outer coat of the crystalline into the vitreous humour | 0·93 |

"From the dimensions of the eye given above, and by means of the preceding indices of refraction, it will be easy to trace, by the method already described, the progress of rays through the humours of the eye, whether they fall upon it in a parallel or a diverging condition.

"Let MN, for example, be an object at a considerable distance from the eye, EFO. Rays of light diverging from the points M, N, will be converged by the refraction of the humours to points *m*, *n*, upon the retina, where they will form an inverted image of it, in the same manner as an image is formed in a camera obscura. That such an image is actually formed on the back of the eye may be easily proved by paring away the sclerotic coat of the eye of an ox, with a sharp knife, till it is sufficiently thin to allow the image to be seen through it.



"In what manner the retina, thus impressed with a distinct image of an external object, conveys to the mind, through the medium of the optic nerve, of which it is the expanded termination, a knowledge of the existence, the position, and the magnitude of that object, is not known, and probably never will be. Certain facts, however, or laws of vision, have been deduced from observation, and merit our attentive consideration.

"1. *On the direction of visible objects.*—When the mind sees the extremity M of any object M N, by means of rays flowing from M and collected at *m*, the retina receives these rays at different degrees of obliquity, and yet the point M is seen only in one direction, namely, in the direction of the central ray of the cone whose apex is at *m*. This however does not arise from the ray being the resultant, as it were, or the mean of the directions of all the other rays; for if we close up all the pupil excepting a small opening at its margin, the point M will be represented at *m* only by the most oblique rays of the conical pencil, and yet it will still be seen in the same direction as before. Hence we conclude, that when a ray of light falls upon any point *m* of the retina, in any direction, however oblique to its surface, the object will be seen in the direction of a line perpendicular to the retina at the point *m*. As the surface of the retina is a portion of a sphere, these perpendiculars must all pass through one point, which may be called the *centre of visible direction;* because every point of an external object will be seen in the direction of a line joining that centre and the given point. The truth of this we have established by marking the perfect stability of the image of any object, when it is seen by different points of the retina when the eyeball alone is moved. Hence the centre of visible direction is a fixed point in the vitreous humour; and as it never changes its place during the rotation of the eyeball, it must be coincident with the centre round which that rotation is performed. In consequence of this coincidence, and in virtue of the law of visible direction, an arrangement of consummate skill, the great Author of nature has provided for the perfect stability of every point in the images of external objects.

"2. *Cause of erect vision.*—As the humours of the eye act exactly like a convex lens of an equivalent focal length, an *inverted* picture of external objects will, for the reasons already assigned be formed upon the retina. Many philosophers of eminence have perplexed themselves very unnecessarily, in attempting to deduce erect vision from inverted images. The law of visible direction removes at once every difficulty; for as the lines of visible direction must necessarily cross each other at the centre of visible direction, those from the lower part of the image must go to the upper part of the object, and those from the upper part of the image go to the lower part of the object, and hence an erect object is the necessary result of an inverted image.

"3. *Distinct and indistinct vision in the same object.*—When we look intensely at any point of an object in order to examine it with care and attention, we direct to that point the axis of the eye, and consequently, the image of that point falls upon the central hole in the retina. Every other point of the same object is seen indistinctly, and the indistinctness increases with the distance of the point from that which is seen distinctly. The only perfectly distinct point of vision, therefore, is that where there is no retina; but we are not entitled to ascribe this to the absence of the nervous matter, as the gradual increase of distinctness towards the central hole does not appear to be accompanied with a gradual dimunition in the thickness of the retina.

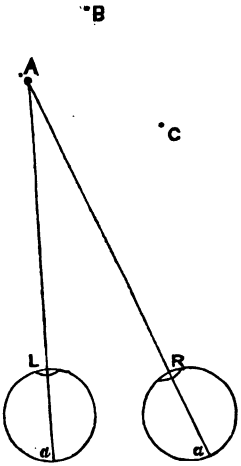
"4. *Indistinctness of vision at the base of the optic nerve.*—It was discovered by M. Mariotte, that when the image of any object fell upon the base of the optic nerve, the object disappeared. In order to prove this experimentally, fix on the side of a room, and at the height of the eye, three wafers, two feet distant. Stand opposite to the middle wafer with one eye shut, and, beginning near the wall, retire gradually from it, (looking always at the outside wafer which is on the same hand as the covered eye,) till the middle wafer disappears. This will be found to take place at about *five* times the distance at which the wafers are placed, and when it does happen, the other wafers will be plainly seen. If we use candles in place of wafers the middle one will not disappear, but it will become a cloudy mass of light. The base of the optic nerve, therefore, is not insensible to light, it is only unfit for giving distinct vision of those objects whose images fall upon it. M. Le Cat considered the size of this portion of the retina to be about one-third or one-fourth of a line; but Daniel Bernoulli found it to be about *one-seventh* part of the diameter of the eye."

The foregoing explanation is clear and accurate, with the exception of some remarks on the direction of visible objects, in paragraph 1. These it is important for us to correct. When a pencil of light from a luminous point M enters the eye and is brought to a focus at *m* upon the retina, the line of visible direction is not the axis of the cone of rays within the vitreous humour of the eye, but a line drawn perpendicular to the retina at the point *m*, and which passes through the centre of the eyeball, or, which is the same thing, through the centre of visible direction, as correctly stated in the latter part of the paragraph referred to in terms which evidently contradict the former part of the same paragraph. If the reader will draw a figure showing the course of an oblique pencil through the eye, he will perceive that the axis of the final cone of rays within the vitreous humour is a line joining the point *m*, with a point somewhere near the pupil of the eye, while the line of visible direction is a line joining *m* with a point near the centre of the eyeball. When the retina receives a blow at *m*, no matter how obliquely, the direction of the supposed force is referred by the mind to a line perpendicular to the retina at *m*.

### *Binocular Vision.*

When both eyes are employed simultaneously vision is said to be "Binocular." The principles of it are easily explained, and will be understood by means of the following figure, and a few words of explanation.

Let L, R, be the two eyes employed simultaneously. Then only one point can be seen distinctly at any instant of time, and that is the point to which both the optic axes are directed and at which they meet, as shown by the point A in the figure. If B, C, be other points, then the mind is simply *warned* of their existence by their images upon the sides of the retinæ, and *distinct* vision of them is not obtained. But the eyeballs are capable of being turned in their sockets with extreme rapidity and precision, and the optic axes may be united at several points in succession by muscular motions which are almost instantaneous, so that it is by the comparison which the mind is able to form of the efforts made by the voluntary muscles in enlarging or contracting the angles LAR, LBR, LCR, that the most certain estimate of the comparative distance of near objects is obtained. Hence arises the important difference between monocular and binocular vision, for by means of the latter additional certainty is given to our appreciation of distance, and hence arise all the remarkable phenomena of stereoscopic effect.



As a proof that only one object is seen distinctly at a time, it is only necessary to hold up the forefinger at a distance of a foot from the nose, and look intently at some object several yards beyond it; the finger will then appear double and transparent, distant objects being seen through it indistinctly.

No idea of the distance of an object can be obtained from the changes which take place in the focussing arrangements of a single eye to suit the different distances of objects between the limits of a few inches and infinity.

VISUAL RAYS. *See* "Perspective."

VITRIOL. "Blue vitriol" is sulphate of copper; "green vitriol" proto-sulphate of iron; "oil of vitriol" sulphuric acid; and "white vitriol" sulphate of zinc.

VOLUME. The space occupied by any solid body is called its "volume."

Volume has *three* dimensions, viz., length, breadth, and thickness; Area *two* dimensions, viz., length and breadth; Length only *one* dimension; and Number *no* dimensions.

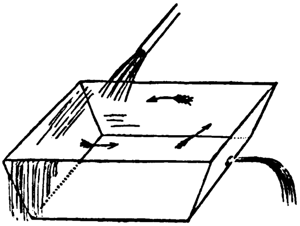
VULCANIZED INDIA-RUBBER, OR GUTTA-PERCHA. These contain sulphur, added chiefly for the purpose of diminishing the stickiness of the surface.

WASHING PRINTS. The following mode of washing prints appears to be the best that has yet been devised. The account of it was given by the author in Photographic Notes, No. 21.

"After a print has been fixed in hypo it is of the utmost importance to remove every trace of hypo from the paper, for if any be left it will cause the print to fade. In order to remove the hypo, the print is generally washed in water changed several times, and allowed to remain in water several hours. But when a great number of prints are to be washed at the same time, a separate dish cannot be provided for each, so it is customary to put a number of prints together in the same vessel of water. When this is done they soon settle to the bottom, and lie there so closely packed that the water cannot easily get between them and soak out the hypo. It is only when the water is agitated by being changed at intervals, and for a few minutes after each change that it gets fairly between them and acts to advantage. It is desirable therefore to keep the water in a state of constant agitation, so that the prints may not lie together; and this is more particularly desirable since it is found that damp favours the action of hypo in causing a print to fade. The object is therefore to remove the hypo as *quickly* and effectually as possible.

"Various plans have been proposed for accomplishing this end; and when a constant supply of water is obtainable, as it is in most large towns, it has been a common practice to leave a tap constantly running into the vessel which contains the prints, the overflow passing into a sink beneath. But the following plan is a great improvement on this, because the prints are caused to circulate freely round the vessel without sticking together, so long as the tap is kept running:—

"The vessel is made as in the figure, with sides slightly inclined outwards, like a washing tray. It should be square, and not too deep, or too large for the supply which is to run into it. The jet of water from the tap is directed obliquely against the further side of it near the left-hand corner; it is then reflected to the adjoining side, and thus a rotatory motion of the fluid in the direction of the arrows is established and maintained. The vessel is of course always full, and the surplus runs over the edge, as shown in the figure. The prints immersed are in this way kept in a state of constant rotation, not *en masse*, but each print following its own particular course, without adhering to its neighbour. In order to insure the change of the water at the bottom of the vessel it may be well to make a little hole about the size of a cribbage peg, as shown in the figure.



"This method of washing paper proofs is extremely simple and effective."

**Water.** $HO=9$. Water may be considered as the protoxide of hydrogen, being composed of one atom of oxygen and one of hydrogen; or, which is the same thing, of two volumes of hydrogen and one of oxygen.

Water in its ordinary state exists either as rain, or river, or spring water.

Rain-water always contains carbonic acid, ammonia, organic matters, and sometimes nitric acid. It becomes putrid when kept. If collected in leaden vessels oxide of lead is readily formed and a small quantity dissolved by it. Rain-water is not suitable for the nitrate bath or developer, although perhaps better than spring-water since it does not contain salts which form precipitates with nitrate of silver.

River and spring waters contain various salts and organic impurities; the principal salts being chloride of sodium, sulphate of lime, and carbonate of lime dissolved in carbonic acid; these produce precipitates or turbidity in the water when nitrate of silver is added to it. Carbonate of lime may be thrown down by boiling the water, which expels the carbonic acid which keeps it in solution. Water is said to be "hard" when it contains salts of lime.

Water may be purified by distillation and condensation of the steam, provided it does not contain volatile oil or empyreumatic matter, which impurities are generally present in the distilled water obtained by condensing the steam from steam boilers. Perfectly pure distilled water for delicate chemical operations is obtained by the redistillation of ordinary distilled water in silver vessels at a low temperature. It is then perfectly neutral to test paper, and a cubic inch of it at 60° weighs 252·5 grains.

Water is very slightly compressible, and when submitted to sudden and violent compression becomes luminous. It freezes at 32°, and boils at 212°. In freezing, or crystallizing, it expands in bulk, therefore ice floats. Water, in freezing, rejects impurities, or salts held in solution, therefore melted ice is very pure water. The combustion of 2 volumes of hydrogen and 1 of oxygen produces 2 volumes of steam. At a mean atmospheric pressure, and temperature 212°, the bulk of steam is 1689 times that of water.

WAX. This substance is supposed to be produced by the bee from the honey which it collects. Its composition is stated by Lowig as $C_{34}\,H_{34}\,O_2$; but it varies, although in every case but one there are as many equivalents of carbon as of hydrogen.

Bees' wax in its ordinary state is yellow, but is bleached by being exposed in thin ribands to the joint action of air, light, and moisture. Sometimes, however, it is bleached more expeditiously by mixing with it nitrate of soda and dilute sulphuric acid, and then traces of sulphate of soda and nitric acid are generally retained. Wax melts at 150°, and is almost entirely soluble in boiling alcohol, and ether; but on cooling the alcohol only retains a small quantity, and the ether none. When caustic potass is added to melted wax, a soapy gelatinous substance is formed which is soluble in a large quantity of water. On adding an acid an oily liquid forms, which solidifies on cooling and is soluble in hot alcohol; it is probably the "Ceraine" of Ettling. Succinic acid is obtained by digesting wax for some days with nitric acid.

Many vegetables secrete wax from their leaves and stems. Instances of this occur as myrtle-wax, palm-wax, Japan-wax, Ocuba-wax, sugar-cane-wax, cork-tree-wax, &c.

White wax is commonly sold in round flat cakes, and is frequently adulterated with tallow, stearine, &c.

Wax may be mixed in any proportions with oil of turpentine. Positive prints, or sheets of paper rubbed with this mixture, acquire a high polish on the evaporation of the turpentine. The ancient fresco paintings upon the walls of houses were varnished and preserved with wax. *See* "Encaustic Painting."

Waxed Paper Process. *See* "Calotype Process," Class 2.

Waxing Apparatus. In the paper negative processes the paper is generally waxed either in the first or last stage of the operation. The best mode of doing this is to procure an oblong apparatus of zinc or pewter, made exactly on the principle of a hot water plate. This is filled with boiling water, and placed over the flame of a spirit lamp to maintain the temperature. The sheet of paper, or paper negative to be waxed is then laid upon the bottom of the upper part of the apparatus, and a cake of wax rubbed over it, until the paper has completely imbibed the wax. It is then removed, and a fresh sheet introduced. When a sufficient number of sheets have been treated in this way, they are held, one at a time, before the fire and the superfluous wax which runs off is collected in a saucer. They are afterwards ironed between sheets of blotting paper, with a moderately hot iron, until no shining patches of wax appear on either side of the paper.

Whey. *See* "Serum of Milk."

White Enamel. Glass rendered white and opaque by the addition of oxide of tin. When ground it forms a beautiful substance to print upon, the negative being copied by a lens, and the wet collodion process employed.

White Lead. Carbonate of lead. This substance should never be ground by hand, but by machinery, as the minute particles which escape into the air are fearfully injurious to the health. The pallid, sickly appearance of painters is mainly attributable to the extensive use of white lead in paint. Zinc paint is not open to the same objection.

**White Fire.** Mix together
24 parts of saltpetre.
7 parts of sulphur.
2 parts of realgar (red sulphide of arsenic).

**Wood Alcohol.** This substance, which is the alcohol of the methyl series, is sometimes called "wood naphtha," and "pyroxylic spirit." It is one of the substances obtained from the destructive distillation of wood, and is purified by redistillation over quicklime. To obtain it pure, Kane adds to it chloride of calcium in excess, and distils the mixture on a water bath as long as volatile matter goes over. (This consists of pyro-acetic spirit and other products.) The compound of wood alcohol and chloride of calcium remains in the retort. To this he adds a quantity of water equal to that of the original spirit, and continues the distillation. The product which now passes over is pure wood alcohol diluted with water, which may be separated by redistillation over quick lime.

Wood alcohol is a limpid liquid, having an aromatic taint, resembling that of peppermint. Its S. G. at 60° is ·800. It mixes in all proportions with water, alcohol, and ether; is neutral to test paper; permanent in the air; and boils at 150°.

This alcohol is extensively used as a solvent in making varnishes, and also collodion. *See* "Methylated Spirits." It closely resembles common alcohol in most of its reactions, but is not liable to duty on account of its hot and pungent taste.

**Wood-Vinegar.** *See* "Pyroligneous Acid."

**Wood, Photographic Engraving upon.** The wood engraver would in many cases derive valuable help from photography, if positive prints could be obtained upon the surface of wooden blocks without injury to the texture of the wood. The following process, which appears to be the best at present known, is extracted from Photographic Notes, No. 40, and is due to M. Lallemand, a well known wood engraver in Paris.

"The inventor of the process which we are about to describe, M. Lallemand, is a skilful engraver. In consequence of his frequent transactions with the editors of works, in the illustration of which wood engraving is often employed, he endeavoured to solve the problem stated above. But at first two difficulties presented themselves. In the first place it was necessary that the wood should not be affected by the photographic chemicals; and secondly, that it should not be so coated or varnished with any substance as to interfere with the operations of the engraver. After more than a year of fruitless experiments, M. Lallemand discovered a process which is free from the above objections, and he has published it in a communication made to the Academy of Sciences, in the following terms:

" 'The surface of the wood (and that only), is submitted to the action of a solution of alum, and dried. The entire block is then coated with a mixture of animal soap, gelatine, and alum. When dry, the surface which is to receive the image is placed for some minutes on a solution of hydrochlorate of ammonia, and allowed to dry. It is next placed in a nitrate bath, containing twenty per cent. of nitrate of silver, and dried in the dark. A negative, either on glass or paper, is then applied to the sensitive surface of the wood, in a pressure-frame made for the purpose, which allows the progress of the printing to be watched. The image is fixed by a saturated solution of hyposulphite of soda. A few minutes in this solution will suffice. It is then washed for *five minutes only.*'

"The sizing protects the wood from any moisture, and eight months' experience has proved to the inventor that the employment of alum and hyposulphite, instead of loosening the texture of the wood, gives it a great toughness, which is favourable to engraving."

XYLOIDINE, NITRAMIDINE. This substance is obtained by the action of nitric acid upon starch, or lignin. By acting on starch with fuming nitric acid a transparent jelly is formed, and on adding water xyloidine is precipitated as a white granular substance. A portion of this is soluble in a dilute solution of caustic potass, and yields a white flocculent precipitate on the addition of acetic acid.

Xyloidine is softened but not dissolved by boiling water, but is soluble in concentrated sulphuric acid, and also in dilute nitric acid; concentrated acetic acid also dissolves xyloidine into a thick mucillage, with which water forms a white coagulum. On evaporating the acetic solution of xyloidine a transparent residue remains, which forms a brilliant varnish when spread upon wood or paper, and resists the action of water.

Xyloidine is nearly insoluble in alcohol. Its composition, according to Ballot, is $C_{15}\ H_{12}\ O_{16}\ N$. It is very inflammable, but not explosive. Cold concentrated nitric acid converts lignin into a substance very similar to the xyloidine obtained from starch; the protracted action of nitric acid on lignin,. aided by heat, yields oxalic acid.

YELLOW CALICO, PAPER, &c. When used for photographic purposes the tint should verge on orange rather than green. Two layers at least should always be employed, because white light passes through the innumerable interstices between the fibres of the calico. Yellow calico is generally bleached by light, and requires to be renewed from time to time.

ZINC. $Zn.=32$. A bluish-white metal of great utility in the arts, and chiefly found either as an oxide, or sulphide. A sheet of polished zinc is readily oxidized by exposure to damp air, but the grey film of oxide formed protects the metal beneath from further oxidation. Commercial zinc is generally contaminated with lead, cadmium, iron, and carbon. Nearly all the metallic oxides are reduced by zinc, which proves its high affinity for oxygen.

ZINC, OXIDE OF. $Zn.O=40$. There is only one salifiable oxide of zinc, viz. the protoxide, which has been called "nihil album," "philosopher's wool," and "flowers of zinc." It is a white, flocculent, tasteless substance, obtained by intensely heating the metal in contact with air, when it burns with a bright flame and produces the oxide. A pigment both in oil and water-colours is made with it; and it is found to combine with oil, and form a dryer in the same way as litharge, being at the same time much less injurious to the painter, and emitting less smell than white lead.

Oxide of zinc combines with water and forms a hydrate. It is readily soluble in acids, and also in the caustic fixed alkalies, and in pure and carbonated ammonia.

## TABLE OF ELEMENTARY BODIES, WITH THEIR EQUIVALENTS; ACCORDING TO BRANDE.

| Symbol. | Name of Substance. | Equivalent. | Symbol. | Name of Substance. | Equivalent. |
|---|---|---|---|---|---|
| Al. | Aluminium . . . | 14 | Hg. | Mercury(Hydrargyrum) | 100 |
| Sb. | Antimony (Stibium) . | 129 | Mo. | Molybdenum . . . | 48 |
| As. | Arsenic . . . . . | 75 | Ni. | Nickel . . . . . | 28 |
| Ba. | Barium . . . . . | 69 | N | Nitrogen . . . . | 14 |
| Bi. | Bismuth . . . . | 213 | Os. | Osmium . . . . . | 100 |
| B | Boron . . . . . | 11 | O | Oxygen . . . . . | 8 |
| Br. | Bromine . . . . | 78 | Pd. | Palladium . . . . | 54 |
| Cd. | Cadmium . . . . | 56 | P | Phosphorus . . . . | 32 |
| Ca. | Calcium . . . . | 20 | Pt. | Platinum . . . . | 99 |
| C | Carbon . . . . . | 6 | K | Potassium (Kalium) . | 40 |
| Ce. | Cerium . . . . . | 46 | R | Rhodium . . . . | 52 |
| Cl. | Chlorine . . . . | 36 | Se. | Selenium . . . . | 40 |
| Cr. | Chromium . . . . | 28 | Si. | Silicium . . . . . | 15 |
| Co. | Cobalt . . . . . | 30 | Ag. | Silver (Argentum) . . | 108 |
| Ta. | Columbium (Tantalum) | 185 | Na. | Sodium (Natrium) . . | 24 |
| Cu. | Copper (Cuprum) . | 32 | Sr. | Strontium . . . . | 44 |
| F | Fluorine . . . . | 19 | S | Sulphur . . . . . | 16 |
| G | Glucinum . . . . | 5 | Te. | Tellurium . . . . | 64 |
| Au. | Gold (Aurum) . . . | 200 | Th. | Thorium . . . . . | 60 |
| H | Hydrogen . . . . | 1 | Sn. | Tin (Stannum) . . . | 59 |
| I | Iodine . . . . . | 126 | Ti. | Titanium . . . . | 24 |
| Ir. | Iridium . . . . . | 99 | W | Tungsten (Wolfram) . | 100 |
| Fe. | Iron (Ferrum) . . . | 28 | U | Uranium . . . . | 60 |
| La. | Lantanum . . . . | 44 | V | Vanadium . . . . | 68 |
| Pb. | Lead (Plumbum) . . | 104 | Y | Yttrium . . . . . | 32 |
| Li. | Lithium . . . . | 7 | Zn. | Zinc . . . . . . | 32 |
| Mg. | Magnesium . . . | 12 | Zr. | Zirconium . . . . | 23 |
| Mn. | Manganese . . . . | 28 | | | |

# BEAUMÉ'S HYDROMETER, OR AREOMETER.

TABLE showing the relation between Specific Gravities and Degrees of Beaumé's Hydrometer, for Liquids heavier than Water.

| S. G. B. | S. G. B. | S. G. B. | S. G. B. | S. G. B. |
|---|---|---|---|---|
| 1·000= 0 | 1·125=16 | 1·286=32 | 1·501=48 | 1·801=64 |
| 1·007= 1 | 1·134=17 | 1·298=33 | 1·526=49 | 1·823=65 |
| 1·014= 2 | 1·143=18 | 1·309=34 | 1·532=50 | 1·847=66 |
| 1·022= 3 | 1·152=19 | 1·321=35 | 1·549=51 | 1·872=67 |
| 1·029= 4 | 1·161=20 | 1·334=36 | 1·566=52 | 1·897=68 |
| 1·036= 5 | 1·171=21 | 1·346=37 | 1·583=53 | 1·921=69 |
| 1·044= 6 | 1·180=22 | 1·359=38 | 1·601=54 | 1·946=70 |
| 1·052= 7 | 1·190=23 | 1·372=39 | 1·618=55 | 1·974=71 |
| 1·060= 8 | 1·199=24 | 1·384=40 | 1·637=56 | 2·002=72 |
| 1·067= 9 | 1·210=25 | 1·398=41 | 1·656=57 | 2·031=71 |
| 1·075=10 | 1·221=26 | 1·412=42 | 1·676=58 | 2·059=74 |
| 1·083=11 | 1·231=27 | 1·426=43 | 1·695=59 | 2·087=75 |
| 1·091=12 | 1·242=28 | 1·440=44 | 1·714=60 | |
| 1·100=13 | 1·252=29 | 1·454=45 | 1·736=61 | |
| 1·108=14 | 1·264=30 | 1·470=46 | 1·758=62 | |
| 1·116=15 | 1·275=31 | 1·485=47 | 1·779=63 | |

In the above scale, 0 corresponds to pure water at 58° Faht., and the numbers 1, 2, 3, &c., correspond to water containing 1, 2, 3, &c., per cent. by weight of common salt.

# TABLE

## For Liquids Lighter than Water.

| S. G. B. | S. G. B. | S. G. B. |
|---|---|---|
| 1·000=10 | ·896=27 | ·811=44 |
| ·993=11 | ·890=28 | ·807=45 |
| ·987=12 | ·885=29 | ·802=46 |
| ·980=13 | ·880=30 | ·798=47 |
| ·973=14 | ·874=31 | ·794=48 |
| ·967=15 | ·870=32 | ·789=49 |
| ·960=16 | ·864=33 | ·785=50 |
| ·954=17 | ·859=34 | ·781=51 |
| ·948=18 | ·854=35 | ·777=52 |
| ·942=19 | ·849=36 | ·772=53 |
| ·936=20 | ·844=37 | ·769=54 |
| ·930=21 | ·840=38 | ·764=55 |
| ·924=22 | ·834=39 | ·760=56 |
| ·918=23 | ·830=40 | ·766=57 |
| ·913=24 | ·825=41 | ·753=58 |
| ·907=25 | ·820=42 | ·749=59 |
| ·901=26 | ·816=43 | ·745=60 |

The Areometer for liquids heavier than water is sometimes called "pèse-acide," or "pèse-syrop;" for liquids lighter than water "pèse-esprit."

# ALCOHOL.

TABLE showing the Proportion by Weight of Absolute Alcohol (S. G. ·7938) contained in 100 parts of Spirits of different Specific Gravities, at 60° Fahrenheit. (*Fownes.*)

| S. G. | Per Cent. of Alcohol. | S. G. | Per Cent. of Alcohol. | S. G. | Per Cent. of Alcohol. | S. G. | Per Cent. of Alcohol. |
|---|---|---|---|---|---|---|---|
| ·9991 | 0·5 | ·9638 | 26 | ·9160 | 51 | ·8581 | 76 |
| ·9981 | 1· | ·9623 | 27 | ·9135 | 52 | ·8557 | 77 |
| ·9965 | 2 | ·9609 | 28 | ·9113 | 53 | ·8533 | 78 |
| ·9947 | 3 | ·9593 | 29 | ·9090 | 54 | ·8508 | 79 |
| ·9930 | 4 | ·9578 | 30 | ·9069 | 55 | ·8483 | 80 |
| ·9914 | 5 | ·9560 | 31 | ·9047 | 56 | ·8459 | 81 |
| ·9898 | 6 | ·9544 | 32 | ·9025 | 57 | ·8434 | 82 |
| ·9884 | 7 | ·9528 | 33 | ·9001 | 58 | ·8408 | 83 |
| ·9869 | 8 | ·9511 | 34 | ·8979 | 59 | ·8382 | 84 |
| ·9855 | 9 | ·9490 | 35 | ·8956 | 60 | ·8357 | 85 |
| ·9841 | 10 | ·9470 | 36 | ·8932 | 61 | ·8331 | 86 |
| ·9828 | 11 | ·9452 | 37 | ·8908 | 62 | ·8305 | 87 |
| ·9815 | 12 | ·9434 | 38 | ·8886 | 63 | ·8279 | 88 |
| ·9802 | 13 | ·9416 | 39 | ·8863 | 64 | ·8254 | 89 |
| ·9789 | 14 | ·9396 | 40 | ·8840 | 65 | ·8228 | 90 |
| ·9778 | 15 | ·9376 | 41 | ·8816 | 66 | ·8199 | 91 |
| ·9766 | 16 | ·9356 | 42 | ·8793 | 67 | ·8172 | 92 |
| ·9753 | 17 | ·9335 | 43 | ·8769 | 68 | ·8145 | 93 |
| ·9741 | 18 | ·9314 | 44 | ·8745 | 69 | ·8118 | 94 |
| ·9728 | 19 | ·9292 | 45 | ·8721 | 70 | ·8089 | 95 |
| ·9716 | 20 | ·9270 | 46 | ·8696 | 71 | ·8061 | 96 |
| ·9704 | 21 | ·9249 | 47 | ·8672 | 72 | ·8031 | 97 |
| ·9691 | 22 | ·9228 | 48 | ·8649 | 73 | ·8001 | 98 |
| ·9678 | 23 | ·9206 | 49 | ·8625 | 74 | ·7969 | 99 |
| ·9665 | 24 | ·9184 | 50 | ·8603 | 75 | ·7938 | 100 |
| ·9652 | 25 | | | | | | |

# ACETIC ACID.

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TABLE SHEWING THE SPECIFIC GRAVITY OF ACETIC ACID AT DIFFERENT DEGREES OF DILUTION. (*Thomson.*)

| Atom of Acid. | | Atoms of Water. | | Specific Gravity at 60°. |
|---|---|---|---|---|
| 1 | + | 1 | = | 1·06296 |
| 1 | + | 2 | = | 1·07060 |
| 1 | + | 3 | = | 1·07084 |
| 1 | + | 4 | = | 1·07132 |
| 1 | + | 5 | = | 1·06820 |
| 1 | + | 6 | = | 1·06708 |
| 1 | + | 7 | = | 1·06349 |
| 1 | + | 8 | = | 1·05974 |
| 1 | + | 9 | = | 1·05794 |
| 1 | + | 10 | = | 1·05439 |

---

# BAROMETER SCALE IN MILLIMÈTRES AND INCHES.

| | | |
|---|---|---|
| 28 inches | = | 711·187 millimètres |
| 29 „ | = | 735·587 „ |
| 30 „ | = | 761·986 „ |
| 31 „ | = | 787·386 „ |
| 1 millimètre | = | 0·03937 inch |
| 1 inch | = | 25·39954 millimètres |

# NITRIC ACID.

TABLE SHOWING THE QUANTITY OF NITRIC ACID IN 100 PARTS OF DILUTE ACID OF DIFFERENT SPECIFIC GRAVITIES. (*Ure.*)

| Specific Gravity of Dilute Acid. | No. of Parts of Liquid Acid, S. G. 1·5 in 100. | Number of Parts of Anhydrous Acid in 100. |
|---|---|---|
| 1·5000 | 100 | 79·7 |
| 1·4880 | 95 | 75·715 |
| 1·4730 | 90 | 71·730 |
| 1·4570 | 85 | 67·745 |
| 1·4385 | 80 | 63·760 |
| 1·4189 | 75 | 59·775 |
| 1·3978 | 70 | 55·790 |
| 1·3732 | 65 | 51·805 |
| 1·3477 | 60 | 47·820 |
| 1·3216 | 55 | 43·835 |
| 1·2947 | 50 | 39·850 |
| 1·2644 | 45 | 35·865 |
| 1·2341 | 40 | 31·880 |
| 1·2019 | 35 | 27·895 |
| 1·1709 | 30 | 23·900 |
| 1·1403 | 25 | 19·925 |
| 1·1109 | 20 | 15·940 |
| 1·0821 | 15 | 11·955 |
| 1·0540 | 10 | 7·970 |
| 1·0267 | 5 | 3·985 |

The intermediate parts may be found with sufficient accuracy by simple proportion.

# TABLE OF THERMOMETRICAL EQUIVALENTS.

| Faht. | Reaumur. | Centigrade. | |
|---|---|---|---|
| 212° | 80° | 100° | Water boils. |
| 200 | 74·66 | 93·33 | |
| 190 | 70·22 | 87·77 | |
| 180 | 65·77 | 82·22 | Alcohol boils. |
| 170 | 61·33 | 76·66 | |
| 160 | 56·88 | 71·11 | |
| 150 | 52·44 | 65·55 | |
| 140 | 48 | 60 | Liquid Ammonia boils. |
| 130 | 43·55 | 54·44 | |
| 120 | 39·11 | 48·88 | |
| 110 | 34·66 | 43·33 | |
| 100 | 30·22 | 37·77 | Blood heat; Ether boils. |
| 90 | 25·77 | 32·22 | |
| 80 | 21·33 | 26·66 | |
| 70 | 16·88 | 21·11 | |
| 60 | 12·44 | 15·55 | |
| 50 | 8 | 10 | Medium temperature of the surface of the earth. |
| 40 | 3·55 | 4·44 | |
| 32 | 0 | 0 | Water freezes. |
| 20 | –5·33 | –6·66 | |
| 10 | –9·77 | –12·22 | |
| 0 | –14·22 | –17·77 | Brine freezes. |
| –10 | –18·66 | –23·33 | Brandy freezes. |
| &c. | &c. | &c. | |

*To reduce Centigrade to Fahrenheit.* Multiply by 9, divide by 5, and add 32.

*To reduce Fahrenheit to Centigrade.* Subtract 32, multiply by 5, and divide by 9.

# FREEZING MIXTURES.

---

## WITHOUT ICE.

| | | |
|---|---|---|
| Muriate of Ammonia | 5 parts | from + 50° to + 10° |
| Nitrate of Potass | 5 „ | |
| Water | 16 „ | |

| | | |
|---|---|---|
| Nitrate of Ammonia | 1 part | from + 50° to + 4° |
| Water | 1 „ | |

| | | |
|---|---|---|
| Sulphate of Soda | 3 parts | from + 50° to − 30° |
| Diluted Nitric Acid | 2 „ | |

## WITH ICE.

| | | |
|---|---|---|
| Snow | 2 parts | to − 5° |
| Salt | 1 „ | |

| | | |
|---|---|---|
| Snow | 12 parts | to − 25° |
| Salt | 5 „ | |
| Nitrate of Ammonia | 5 „ | |

| | | |
|---|---|---|
| Snow | 4 parts | from 32° to − 40° |
| Chloride of Calcium | 5 „ | |

| | | |
|---|---|---|
| Snow | 7 parts | from 32° to − 30° |
| Diluted Nitric Acid | 4 „ | |

| | | |
|---|---|---|
| Snow | 3 parts | from + 32° to − 51° |
| Potassa | 4 „ | |

# ENGLISH IMPERIAL MEASURES.

## LONG MEASURE.

The imperial yard bears to the length of a pendulum vibrating seconds of mean time in vacuo, at the sea level, in the latitude of London, the ratio 36 : 39·1393.

1 inch
12 = 1 foot
36 = 3 = 1 yard
72 = 6 = 2 = 1 fathom
198 = 16½ = 5½ = 1 pole, perch, or rod
7920 = 660 = 220 = 40 = 1 furlong
63360 = 5280 = 1760 = 320 = 8 = 1 mile

## IMPERIAL MEASURE.

The imperial gallon is the volume occupied by 10 pounds avoirdupois weight of distilled water, weighed in air at 62° Faht., the barometer being at 30 inches.

| | Equivalents in Troy grains. Distilled water 62° Faht. |
|---|---|
| 1 pint . . . . . . . . . . | 8750 |
| 2 = 1 quart . . . . . . . | 17500 |
| 8 = 4 = 1 gallon . . . . . . | 70000 |
| 16 = 8 = 2 = 1 peck . . . . | 140000 |
| 64 = 32 = 8 = 4 = 1 bushel . . | 560000 |
| 512 = 256 = 64 = 32 = 8 = 1 quarter . | 4480000 |

## APOTHECARIES MEASURE.

| | Troy grains. Distilled water at 62° Faht. |
|---|---|
| 1 minim . . . . . . . . . . | 0.91 |
| 60 = 1 fluid drachm . . . . . . | 54·7 |
| 480 = 8 = 1 fluid ounce . . . | 437·5 |
| 9600 = 160 = 20 = 1 pint . . . | 8750· |
| 76800 = 1280 = 160 = 8 = 1 gallon . | 70000· |

## IMPERIAL CUBIC MEASURE.

| | | Equivalents in cubic inches. | | Equivalents in Troy grains. Distilled water at 62° Faht. |
|---|---|---|---|---|
| 1 gallon | = | 277·274 | = | 70000 |
| 1 quart | = | 69·3185 | = | 17500 |
| 1 pint | = | 34·65925 | = | 8750 |
| 16 ounces | = | 27·72740 | = | 7000 |
| 1 ounce | = | 1·73296 | = | 437·5 |

# ENGLISH IMPERIAL WEIGHTS.

The grain is the same in Troy, Apothecaries, and Avoirdupois weights.

## AVOIRDUPOIS WEIGHT.

|  |  |  |  |  |  | **Equivalent in Troy grains.** |
|---|---|---|---|---|---|---|
| 1 dram |  |  |  |  |  | 27·34375 |
| 16= | 1 ounce |  |  |  |  | 437·5 |
| 256= | 16= | 1 pound |  |  |  | 7000· |
| 3584= | 224= | 14= | 1 stone |  |  | 98000· |
| 28672= | 1792= | 112= | 8= | 1cwt. |  | 784000· |
| 473440= | 35840= | 2240= | 160= | 20= | 1 ton | 15680000· |

## TROY WEIGHT.

1 grain.
24 = 1 pennyweight.
480 = 20 = 1 ounce.
5760 = 240 = 12 = 1 pound.

## APOTHECARIES WEIGHT.

|  |  |  |  |  | **Symbols.** |
|---|---|---|---|---|---|
| 1 grain |  |  |  |  | gr. |
| 20 = | 1 scruple |  |  |  | ℈ |
| 60 = | 3 = | 1 drachm |  |  | ʒ |
| 480 = | 24 = | 8 = | 1 ounce |  | ℥ |
| 5760 = | 288 = | 96 = | 12 = | 1 pound | ℔ |

Observe: 437·5 grains are considered equal to 1 ounce of nitrate of silver; that salt being sold according to the Dublin weights, in which the scruple is only equal to 18·22 grains, and the ounce equal in weight to a fluid ounce of distilled water at 62° Faht.

## FRENCH WEIGHTS.

| | | | | Troy Weight. | | | |
|---|---|---|---|---|---|---|---|
| | | Troy Grains. | | Lbs. | Ozs. | Drms. | Grains. |
| Millegramme | = | ·0154 | | | | | |
| Centigramme | = | ·1543 | | | | | |
| Decigramme | = | 1·543 | = | | | | 1·5 |
| GRAMME | = | 15·432 | = | | | | 15·4 |
| Decagramme | = | 154·323 | = | | | 2 | 34 |
| Hectograme | = | 1543·234 | = | | 3 | 1 | 43 |
| Kilogramme | = | 15432·348 | = | 2 | 8 | 1 | 12 |
| Myriagramme | = | 154323·488 | = | 26 | 9 | 4 | 3 |

## FRENCH MEASURE OF LENGTH.

| | | | | English. | | | | |
|---|---|---|---|---|---|---|---|---|
| | | English Inches. | | Miles. | Furlongs. | Yards. | Feet. | Inches. |
| Millimètre | = | ·03937 | | | | | | |
| Centimètre | = | ·39371 | | | | | | |
| Decimètre | = | 3·93708 | | | | | | |
| METRE | = | 39·37079 | = | | | 1 | 0 | 3·7 |
| Decamètre | = | 393·70790 | = | | | 10 | 2 | 9·7 |
| Hectomètre | = | 3937·079 | = | | | 109 | 1 | 1 |
| Kilomètre | = | 39370·79 | = | | 4 | 213 | 1 | 10 |
| Myriamètre | = | 393707·9 | = | 6 | 1 | 156 | 0 | 0 |

The Mètre is the length of a second's pendulum at Paris.
The Kilomètre is rather more than half a mile.

## FRENCH MEASURE OF CAPACITY.

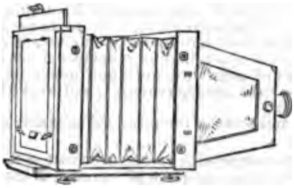
| | | | | English | | | | |
|---|---|---|---|---|---|---|---|---|
| | | English Cubic Inches. | | Gallons. | Pints. | Fluid Ozs. | Drms. | Minims. |
| Millitre | = | ·0610 | = | | | | | 16·9 |
| Centilitre | = | ·6103 | = | | | | 2 | 50 |
| Decilitre | = | 6·1027 | = | | | 3 | 4 | 13 |
| LITRE | = | 61·027 | = | | 1 | 15 | 2 | 11 |
| Decalitre | = | 610·27 | = | 2 | 1 | 12 | 5 | 51 |
| Hectolitre | = | 6102·7 | = | 22 | 0 | 7 | 3 | 8 |
| Kilolitre | = | 61027· | = | 220 | 3 | 13 | 7 | 30 |
| Myrialitre | = | 610270· | = | 2204 | 4 | 10 | 3 | |

The French Litre is not quite an English Quart.

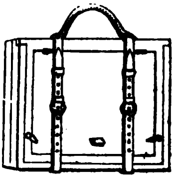
# T. OTTEWILL & CO.'S

# NEW TEAK CAMERAS FOR INDIA.

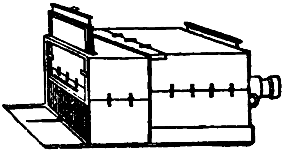
Capt. Fowke's Camera Open.



Capt. Fowke's Camera Shut.



T. Ottewill's Registered Camera.



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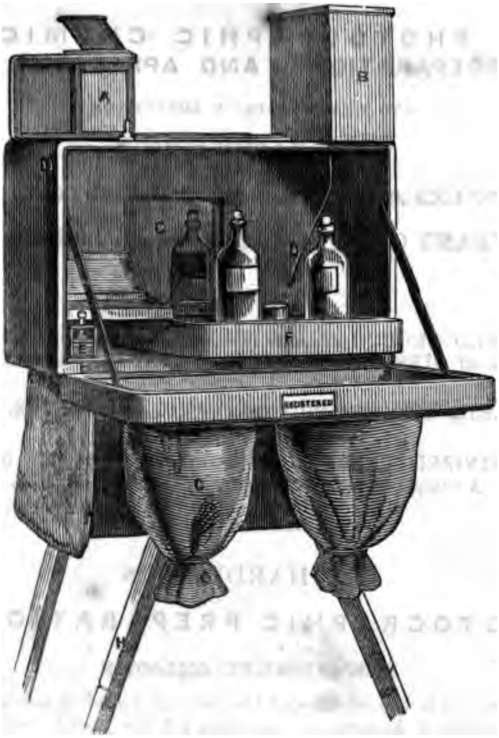
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